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Report on Human Biomonitoring of Environmental Chemicals in Canada

Results of the Canadian Health Measures Survey Cycle 1 (2007–2009)

Canada

ERRATA

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8.8.2 *cis*-3-(2,2-Dibromovinyl)-2,2-Dimethylcyclopropane-1-Carboxylic Acid (*cis*-DBCA) 253

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8.1.13 Zinc (CASRN 7440-66-6)

Zinc was measured in the blood and urine of all participants aged 6–79 years in the Canadian Health Measures Survey and is presented as mg/L in blood and as both µg/L and µg/g creatinine in urine (Tables 8.1.13a, 8.1.13b, 8.1.13c). Finding a measurable amount of zinc in blood or urine is an indicator of exposure to zinc and does not necessarily mean that an adverse health effect will occur. Since it is an essential nutrient, its presence is expected. These data provide reference ranges for blood and urinary levels of zinc in the Canadian population.

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■ Table 8.1.13a

Zinc – Arithmetic and geometric means, and selected percentiles of blood concentrations (mg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

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8.8.2 *cis*-3-(2,2-Dibromovinyl)-2,2-Dimethylcyclopropane-1-Carboxylic Acid (*cis*-DBCA)

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Metals and Trace Elements in Urine	
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Appendix B

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Report on Human Biomonitoring of Environmental Chemicals in Canada

Results of the Canadian Health Measures Survey Cycle 1 (2007–2009)

August 2010

Health Canada is the federal department responsible for helping the people of Canada maintain and improve their health. *We assess the safety of drugs and many consumer products, help improve the safety of food, and provide information to Canadians to help them make healthy decisions. We provide health services to First Nations people and to Inuit communities. We work with the provinces to ensure our health care system serves the needs of Canadians.*

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Report on Human Biomonitoring of Environmental Chemicals in Canada
is available on Internet at the following address:
www.healthcanada.gc.ca

Également disponible en français sous le titre :
Rapport sur la biosurveillance humaine des substances chimiques de l'environnement au Canada

This publication can be made available on request on diskette, large print, audio-cassette and braille.

For further information or to obtain additional copies, please contact:
Publications
Health Canada
Ottawa, Ontario K1A 0K9
Tel.: 613-954-5995
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Email: info@hc-sc.gc.ca

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Cat.: H128-1/10-601E
ISBN: 978-1-100-15618-7

Acknowledgements

The development and implementation of the biomonitoring component of the Canadian Health Measures Survey was achieved through extensive contributions of programs and staff across Health Canada and Statistics Canada. A special thank you goes out to the participants of the survey, without whom this study would not be possible.

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INTRODUCTION 1

The *Report on Human Biomonitoring of Environmental Chemicals in Canada* presents national baseline data on concentrations of environmental chemicals in Canadians. These data were collected as part of Cycle 1 of the Canadian Health Measures Survey (CHMS), the most comprehensive national direct health-measures survey conducted in Canada to date. Statistics Canada, in partnership with Health Canada and the Public Health Agency of Canada, launched the CHMS to collect health and wellness data and biological specimens on a nationally representative sample of Canadians. Data were collected between March 2007 and February 2009 from approximately 5,600 Canadians aged 6–79 years at 15 sites across Canada, from Moncton to Vancouver. Collection for the second cycle of the CHMS began in September 2009 and includes children as young as 3 years of age. Cycle 2 will be completed in 2011, while planning for future cycles is underway.

The CHMS biomonitoring component, the first study of its kind in Canada, measured environmental chemicals and/or their metabolites, in blood and urine of survey participants. For the purposes of this report, an environmental chemical is defined as a chemical substance, either man-made or natural, that is present in the environment and to which humans may be exposed through media such as air, water, food, soil, dust, or consumer products.

In this report, the general CHMS survey design and implementation are described, with emphasis on the biomonitoring component. This is followed by descriptive summaries for each chemical, outlining the chemical's identity, common uses, occurrence in the environment, potential sources of exposure in the human population, toxicokinetics in the body, and health effects. Finally, data tables specific to each chemical are provided, with descriptive statistics on the distribution of blood and/or urine concentrations in the sample population.

OBJECTIVES 2

The primary purpose of the *Report on Human Biomonitoring of Environmental Chemicals in Canada* is to provide human biomonitoring data to scientists, and health and environment officials, to aid in assessing the exposure to environmental chemicals and assessing policies to reduce exposure to chemicals for the protection of the health of Canadians.

Some specific uses of the information presented in this report could include the following:

- to establish reference ranges for concentrations of chemicals in Canadians, which could allow for comparisons with subpopulations in Canada and comparisons with other countries;
- to establish baseline levels of chemicals to track trends of exposure levels in Canadians over time;
- to provide information for setting priorities and taking action to protect the health of Canadians and to protect Canadians from exposure to environmental chemicals;
- to assess the effectiveness of regulatory and environmental risk management actions intended to reduce exposures and health risks from specific chemicals;
- to support future research on potential links between exposure to certain chemicals and specific health effects; and,
- to contribute to international monitoring programs, such as the Stockholm Convention on Persistent Organic Pollutants.

SURVEY DESIGN 3

The CHMS was designed as a cross-sectional survey to address important data gaps and limitations in existing health information in Canada. Its principal objective is to collect national-level baseline and reference ranges on important indicators of Canadians' health status, including those pertaining to exposures to environmental chemicals. This information is important in understanding health risk factors, detecting emerging trends in risk factors and exposures, advancing health surveillance and research, and assessing the effectiveness of actions by government and others in Canada. Detailed descriptions of the CHMS rationale, survey design, sampling strategy, clinic operations and logistics, and ethical, legal and social issues, have previously been published (Tremblay et al., 2007; Giroux, 2007; Day et al., 2007; Bryan et al., 2007; Statistics Canada, 2010).

3.1 TARGET POPULATION

The CHMS targets the population aged 6 to 79 years living at home and residing in the ten provinces and three territories. People living on reserves or in other Aboriginal settlements in the provinces, residents of institutions, full-time members of the Canadian Forces, persons living in certain remote areas, and persons living in areas with a low population density were excluded.

3.2 SAMPLE SIZE AND ALLOCATION

To meet the objective of producing reliable estimates at the national level by age group and sex, the CHMS required a sample of at least 5000 persons equally distributed among five age groups (6–11, 12–19, 20–39, 40–59, and 60–79 years) and sex, for a total of ten groups.

3.3 SAMPLING STRATEGY

To meet the requirements of the CHMS, a multistage sampling strategy was used.

3.3.1 Sampling of Collection Sites

The CHMS required participants to report to a mobile examination centre (MEC) and be able to travel to that clinic within a reasonable period of time. The Canadian Labour Force Survey (LFS) sampling frame was used to create 257 collection sites across the country. A collection site is a geographic area with a population of at least 10,000 and a maximum respondent travel distance of 100 kilometres (50 kilometres in urban areas and 100 kilometres in rural areas). Areas not meeting these criteria were excluded. Nonetheless, the CHMS covers 96.3% of the Canadian population aged 6 to 79 (Statistics Canada, 2010).

A large number of collection sites with few respondents would have optimized the precision of the estimates. However, the logistical and cost constraints associated with the use of mobile examination centres restricted the number of collection sites to 15. The 15 collection sites were selected from within the five standard regional boundaries used by Statistics Canada (Atlantic, Quebec, Ontario, Prairies [including Yellowknife], and British Columbia [including Whitehorse]) and were allocated to these regions in proportion to the size of the population. While not every province and territory in Canada had a collection site, the CHMS sites were chosen to represent the Canadian population, East to West, including larger and smaller population densities. The collection sites selected for Cycle 1 of the CHMS are listed in Table 1 (Statistics Canada, 2010).

Table 1
Canadian Health Measures Survey Cycle 1 collection site

Atlantic	Quebec	Ontario	Prairies	British Columbia
• Moncton, New Brunswick	• Quebec City • Montreal • Montérégie • South Mauricie	• Clarington • North York • Don Valley • St. Catharine's–Niagara • Kitchener–Waterloo • Northumberland County	• Edmonton, Alberta • Red Deer, Alberta	• Vancouver • Williams Lake and Quesnel

3.3.2 Dwelling and Respondent Sampling

The 2006 Canadian Census was used as the frame to select dwellings. Within each site, dwellings with known household composition at the time of the 2006 Census were stratified by age of household residents at the time of the survey, with the five age-group strata corresponding to the CHMS age groups (6–11, 12–19, 20–39, 40–59, 60–79). Within each site, a simple random sample of dwellings was selected in each stratum. Each selected dwelling was then contacted and asked to provide a list of current household members, and this list was used to select the survey respondents. One or two people were selected, depending on the household composition.

3.4 SELECTION OF ENVIRONMENTAL CHEMICALS

The environmental chemicals selected for inclusion in the CHMS were based on the results of an expert workshop on Human Biomonitoring of Environmental Chemicals hosted by Health Canada in 2003 and on subsequent consultations with various Health Canada programs and Statistics Canada. The expert workshop had representation from the Canadian government, academia, public health agencies, public health and medical laboratories, and the US Centers for Disease Control and Prevention. Substances were selected from an initial candidate list of over 220 individual chemicals and/or groups of environmental chemicals. Selection was based on health risks, evidence of human exposure, existing data gaps, obligations under national and international treaties, conventions and agreements, availability of standard laboratory analytical methods, and current and anticipated health policy development and implementations.

The environmental chemicals selected for biomonitoring in the Canadian Health Measures Survey were chosen based on one or more of the following criteria:

- known or suspected health effects related to the substance;
- need for public health actions related to the substance;
- level of public concern about exposures and possible health effects related to the substance;
- evidence of exposure of the Canadian population to the substance;
- feasibility of collecting biological specimens in a national survey and associated burden on survey respondents;
- availability and efficiency of laboratory analytical methods;
- costs of performing the test; and,
- parity of selected chemicals with other national and international surveys and studies.

Ultimately the list was narrowed by the volume of biospecimen available from survey participants to conduct the analysis. Blood volume is generally limited, thus the number of environmental chemicals measured in blood is less than that analyzed in urine. In addition, blood collected was also required for analysis of chronic and infectious diseases and nutritional biomarkers. Some analytes were measured because the analytical method used, such as the ICP-MS method for the metal panel, provided results for additional chemicals with little or no additional biospecimen volume and cost, including essential nutrients such as copper, molybdenum, selenium, and zinc, which are required for maintenance of good health. A full list of the chemicals measured in CHMS 2007–2009 is presented in Table 2.

Table 2

Chemicals Measured in the Canadian Health Measures Survey 2007–2009

Metals and Trace Elements
Antimony
Arsenic
Cadmium
Copper
Lead
Manganese
Mercury
Molybdenum
Nickel
Selenium
Uranium
Vanadium
Zinc

Organochlorines
Aldrin
Chlordane
α-Chlordane
γ-Chlordane
cis-Nonachlor
trans-Nonachlor
Oxychlordane
DDT
p,p'-DDT (*p,p'*-Dichlorodiphenyltrichloroethane)
p,p'-DDE (*p,p'*-Dichlorodiphenyldichloroethylene)
Hexachlorobenzene
Hexachlorocyclohexane
β-Hexachlorocyclohexane
γ-Hexachlorocyclohexane
Mirex
Toxaphene
Toxaphene Parlar 26
Toxaphene Parlar 50

Polychlorinated Biphenyls

PCB 28 (2,4,4'-Trichlorobiphenyl)
PCB 52 (2,2',5,5'-Tetrachlorobiphenyl)
PCB 66 (2,3',4,4'-Tetrachlorobiphenyl)
PCB 74 (2,4,4',5-Tetrachlorobiphenyl)
PCB 99 (2,2',4,4',5-Pentachlorobiphenyl)
PCB 101 (2,2',4,5,5'-Pentachlorobiphenyl)
PCB 105 (2,3,3',4,4'-Pentachlorobiphenyl)
PCB 118 (2,3',4,4',5-Pentachlorobiphenyl)
PCB 128 (2,2',3,3',4,4'-Hexachlorobiphenyl)
PCB 138 (2,2',3,4,4',5'-Hexachlorobiphenyl)
PCB 146 (2,2',3,4',5,5'-Hexachlorobiphenyl)
PCB 153 (2,2',4,4',5,5'-Hexachlorobiphenyl)
PCB 156 (2,3,3',4,4',5-Hexachlorobiphenyl)
PCB 163 (2,3,3',4',5,6-Hexachlorobiphenyl)
PCB 167 (2,3',4,4',5,5'-Hexachlorobiphenyl)
PCB 170 (2,2',3,3',4,4',5-Heptachlorobiphenyl)
PCB 178 (2,2',3,3',5,5',6-Heptachlorobiphenyl)
PCB 180 (2,2',3,4,4',5,5'-Heptachlorobiphenyl)
PCB 183 (2,2',3,4,4',5',6-Heptachlorobiphenyl)
PCB 187 (2,2',3,4',5,5',6-Heptachlorobiphenyl)
PCB 194 (2,2',3,3',4,4',5,5'-Octachlorobiphenyl)
PCB 201 (2,2',3,3',4,5',6,6'-Octachlorobiphenyl)
PCB 203 (2,2',3,4,4',5,5',6-Octachlorobiphenyl)
PCB 206 (2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl)
Aroclor 1260

Polybrominated Flame Retardants

PBB 153 (2,2',4,4',5,5'-Hexabromobiphenyl)
PBDE 15 (4,4'-Dibromodiphenyl Ether)
PBDE 17 (2,2',4-Tribromodiphenyl Ether)
PBDE 25 (2,3',4-Tribromodiphenyl Ether)
PBDE 28 (2,4,4'-Tribromodiphenyl Ether)
PBDE 33 (2',3,4-Tribromodiphenyl Ether)
PBDE 47 (2,2',4,4'-Tetrabromodiphenyl Ether)
PBDE 99 (2,2',4,4',5-Pentabromodiphenyl Ether)
PBDE 100 (2,2',4,4',6-Pentabromodiphenyl Ether)
PBDE 153 (2,2',4,4',5,5'-Hexabromodiphenyl Ether)

Perfluorinated Compounds

PFOS (Perfluorooctane Sulfonate)
PFOA (Perfluorooctanoic Acid)
PFHxS (Perfluorohexane Sulfonate)

Phenoxy Herbicide

2,4-D (2,4-Dichlorophenoxyacetic Acid)

Environmental Phenol

Bisphenol A

Chlorophenol

2,4-DCP (2,4-Dichlorophenol)

Tobacco

Cotinine

Organophosphate Insecticides (Metabolites)

DMP (Dimethylphosphate)
DMTP (Dimethylthiophosphate)
DMDTP (Dimethyldithiophosphate)
DEP (Diethylphosphate)
DETP (Diethylthiophosphate)
DEDTP (Dimethyldithiophosphate)

Pyrethroid Insecticides (Metabolites)

4-F-3-PBA (4-Fluoro-3-Phenoxybenzoic Acid)
cis-DBCA (*cis*-3-(2,2-Dibromovinyl)-2,2-Dimethylcyclopropane Carboxylic Acid)
cis-DCCA (*cis*-3-(2,2-Dichlorovinyl)-2,2-Dimethy-Dimethylcyclopropane Carboxylic Acid)
trans-DCCA (*trans*-3-(2,2-Dichlorovinyl)-2,2-Dimethylcyclopropane Carboxylic Acid)
3-PBA (3-Phenoxybenzoic Acid)

Phthalates (Metabolites)*

MBzP (Mono-benzyl Phthalate)
MnBP (Mono-n-butyl Phthalate)
MEP (Mono-ethyl Phthalate)
MCHP (Mono-cyclohexyl Phthalate)
MiNP (Mono-isononyl Phthalate)
MMP (Mono-methyl Phthalate)
MOP (Mono-n-octyl Phthalate)
MCPP (Mono-3-carboxypropyl Phthalate)
MEHP (Mono-2-ethylhexyl Phthalate)
MEOHP (Mono-(2-ethyl-5-oxohexyl) Phthalate)
MEHHP (Mono-(2-ethyl-5-hydroxyhexyl) Phthalate)

* Phthalate metabolites were measured in Cycle 1 of the CHMS, but the data are not presented in this report due to an ongoing quality assurance investigation into accuracy of the analytical standards used in the laboratory analysis.

Due to the high cost of laboratory analysis, some environmental chemicals were measured in subsamples from the CHMS respondents. Subsamples for specific environmental chemicals were independently selected, and as such, a specific respondent could have been selected for measurement of one, two, or all of the environmental chemicals. Consequently, the age range for which a chemical was measured varied by chemical (Table 3). A collocated sampling method was used to minimize the selection of two people living in the same household (6–11 year olds and other age groups) for the same environmental chemical measurement in order to maximize the representativeness of the population sample (Giroux, 2007). Further details on the subsampling for environmental chemicals are available in the *Canadian Health Measures Survey (CHMS) Data User Guide: Cycle 1* (Statistics Canada, 2010).

Table 3

Environmental chemicals measured by age group

Measure	Matrix	Target Sample Size	Age (years)				
			6–11	12–19	20–39	40–59	60–79
Metals and trace elements	Urine and Blood	5600	■	■	■	■	■
Organochlorines	Plasma	1500			■	■	■
Polychlorinated biphenyls (PCBs)	Plasma	1500			■	■	■
Polybrominated flame retardants (PBB & PBDEs)	Plasma	1500			■	■	■
Perfluorinated compounds (PFCs)	Plasma	1500			■	■	■
Bisphenol A	Urine	5600	■	■	■	■	■
Organophosphate insecticides	Urine	5600	■	■	■	■	■
Pyrethroid insecticides	Urine	5600	■	■	■	■	■
Phenoxy herbicide	Urine	5600	■	■	■	■	■
Chlorophenol	Urine	5600	■	■	■	■	■
Cotinine	Urine	5600	■	■	■	■	■

3.5 ETHICAL CONSIDERATIONS

Personal information collected through the CHMS is protected under the federal *Statistics Act*. Under this Act, Statistics Canada is obliged to safeguard and to keep in trust the information it obtains from the Canadian public. Consequently, Statistics Canada has established a comprehensive framework of policies, procedures, and practices to protect confidential information against loss, theft, unauthorized access, disclosure, copying, or use, which includes physical, organizational, and technological measures. The steps taken by Statistics Canada to safeguard the information collected in the CHMS have been described previously by Day et al. (2007).

Ethics approval for all components of the CHMS was obtained from Health Canada's Research Ethics Board. Informed written consent for the clinic portion of the CHMS was obtained from respondents older than 14 years of age. For younger children, a parent or legal guardian provided written consent and the child provided written assent. Participation in this survey was voluntary and respondents could opt out of any part of the survey at any time.

A strategy was developed to communicate results to survey respondents with the advice and expert opinion of the CHMS Laboratory Advisory Committee, the Physician Advisory Committee, and Health Canada's Research Ethics Board (Day et al., 2007). For the environmental chemicals, only results for lead, mercury, and cadmium were actively reported to respondents. However, respondents could receive all other test results upon request to Statistics Canada. More information on reporting to respondents can be found in Haines et al. (2010).

FIELDWORK 4

Fieldwork for the CHMS took place over two years from March 2007 to February 2009. Data were collected sequentially at 15 sites across Canada. The sites were ordered to take into account seasonality by region and the temporal effect, subject to operational and logistical constraints. The temporal effect means that the number of sites by region were distributed evenly in year one and year two, with the exception of the Atlantic region, which had only one site (Giroux, 2007).

Respondents were contacted by Statistics Canada through an advance letter and brochure mailed to the household informing them they would be contacted to participate in the survey.

Data collection included a combination of a household personal interview using a computer-assisted interviewing method and for the physical measures, a clinic visit to a Mobile Examination Centre (MEC) specifically designed for the survey. The field team consisted of household interviewers and the CHMS MEC staff, including trained health professionals who performed the physical measures testing. Respondents were first administered a household questionnaire in their home by an interviewer and, within approximately two weeks, the respondents visited an MEC where trained health professionals took the physical health measurements and collected the blood and urine specimens. Biospecimens were processed and stored prior to shipment to the CHMS laboratories.

When visiting the home, the interviewer randomly selected one or two respondents and conducted separate 45 to 60 minute health interviews. This interview collected demographic and socioeconomic data and information about lifestyle, medical history, current health status, the environment, and housing conditions.

Each MEC consisted of two trailers linked by an enclosed pedestrian walkway. One trailer served as a reception and administration area, while the other contained clinic rooms and a laboratory. At the MEC, health professionals took the respondents' physical measurements, such as height, weight, blood pressure, lung function, and physical fitness, and collected their blood and urine specimens.

The MEC operated seven days a week in order to complete approximately 350 clinic visits at each site over six to eight weeks and to accommodate respondents' schedules. Clinic appointments averaged about 2.5 hours. Children under 14 years of age were accompanied by a parent or legal guardian. To maximize response rates, respondents who were unable or unwilling to go to the clinic were offered the option of a home visit to perform the physical measures portion of the survey.

At the start of the clinic visit, respondents signed the consent/assent forms prior to any testing and immediately thereafter provided a urine sample.

For logistical purposes, spot samples were collected rather than 24-hour urine samples. Urine samples were collected in 120-mL urine specimen containers.

The respondents were administered a series of screening questions to determine the respondents' eligibility for the various tests, including phlebotomy (i.e., blood collection), based on pre-existing exclusion criteria. Blood specimens were drawn by a certified phlebotomist and the amount of blood drawn was dependent upon the age of the respondent. For children aged 6 to 11 years, approximately 28 mL was drawn; for 12 to 13 years, 38 mL; for 14 to 19 years, 45 mL; and for 20 to 79 years, 75 mL.

All blood and urine specimens collected in the MEC were processed in the MEC, including aliquoting and centrifuging of serum and plasma. Two -20°C freezers were used to temporarily store the biospecimens until shipping. Once a week, the specimens were shipped to the reference laboratory for analysis. Standardized operating procedures (SOPs) were developed for the collection of blood and urine specimens, processing and aliquoting procedures as well as for shipping biospecimens to ensure adequate quality of the data and to standardize data collection. A priority sequence for laboratory analysis was established in the event that an insufficient volume of biospecimen was collected for complete analysis of the environmental chemicals, as well as for analysis of infectious diseases, nutritional status, diabetes, and cardiovascular disease risk factors. Details on the reference laboratory, collection tubes, aliquot volumes, temporary storage and shipping requirements, and priority testing are presented in Table 4.

Table 4

Urine and blood collection, storage, and shipping procedure for the environmental chemicals (in order of testing priority for environmental chemicals)

Measure	Matrix	Reference Laboratory[a]	Collection Tube (size and type[b])	Aliquot Volume[c]	Storage[d]/ Shipping
Lipids: triglycerides & total cholesterol	Serum	HC	8.5 mL Red/Grey SST	1.0 mL	freezer/dry ice
Metals and trace elements & inorganic mercury	Whole Blood	INSPQ	6.0 mL Lavender EDTA	1.8 mL	freezer/ice pack
PCBs, organochlorines, PBB & PBDEs	Plasma	INSPQ	10.0 mL Lavender EDTA	2.7 mL	freezer/ice pack
Perfluorinated compounds	Plasma	INSPQ	10.0 mL Lavender EDTA	1.8 mL	freezer/dry ice
Creatinine & cotinine	Urine	INSPQ	Urine specimen container	4.5 mL	freezer/dry ice
Metals and trace elements & inorganic mercury	Urine	INSPQ	Urine specimen container	4.5 mL	freezer/dry ice
Bisphenol A, organophosphate insecticides, pyrethroid insecticides, phenoxy herbicide & chlorophenol	Urine	INSPQ	Urine specimen container	20.0 mL	freezer/ice pack

[a] HC = Health Canada Nutrition Laboratory, INSPQ = Institut national de santé publique du Québec

[b] Becton Dickinson Vacutainers were utilized for the collection of blood; VWR urine specimen containers were utilized for the collection of urine

[c] Aliquot volume = total sample volume sent to the reference laboratory

[d] Mobile Examination Clinic freezers were set at -20°C

To maximize the reliability and validity of the data and to reduce systematic bias, the CHMS developed quality assurance and quality control protocols for all aspects of the fieldwork. Quality assurance for the clinic covered staff selection and training, instructions to respondents (pre-testing guidelines) and issues related to data collection. All staff had appropriate education and training for their respective positions. To ensure consistency among measurement techniques, procedures manuals and training guides were developed in consultation with, and reviewed by, experts in the field. Quality control samples at each site consisted of one field blank (bovine serum for the perfluorinated chemicals and de-ionized water for all analytes) and blind commercial control samples for arsenic, cadmium, lead and mercury in whole blood. These quality control samples were sent to the reference laboratory with a regular specimen shipment. Results were sent to Statistics Canada's CHMS headquarters, along with all other respondent results, where they were assessed to determine the accuracy of the methodology based on the defined analyte concentration. If required, feedback was provided quickly to the reference laboratory for review and remedial action. During this quality assurance process, it was determined that the vacutainers used in the blood metal analysis were contaminated with manganese and a correction factor of 14 nmol/L was applied to all blood manganese results to account for this contamination.

Detailed descriptions of the CHMS clinic operations and logistics have been described previously in Bryan et al., (2007) and Giroux (2007), and are presented in the *Canadian Health Measures Survey (CHMS) Data User Guide: Cycle 1* (Statistics Canada, 2010).

LABORATORY ANALYSIS 5

Laboratory analysis of environmental chemicals and creatinine was performed at the Centre de toxicologie du Québec (CTQ) of L'Institut national de santé publique du Québec (INSPQ), Québec City. INSPQ followed standardized operating procedures that were developed for every assay and technique performed in their laboratory. The laboratory, which is accredited under ISO 17025, uses numerous internal and external quality control programs. Laboratory analysis of serum lipids was performed at the Health Canada laboratories, Bureau of Nutritional Sciences, Nutrition Research Division, Ottawa. This lab also uses numerous internal and external quality control programs and is a member of a proficiency testing program. The limit of detection (LOD) for each method is presented in Appendix B.

Internal quality control measures within INSPQ include the use of calibration standards, laboratory blanks and other in-house reference materials. External quality control measures include participation in inter-laboratory comparison studies for most analytes. Quality assurance reviews were conducted on laboratory data for each site, in order to identify inconsistencies in results, such as assay drifting. In particular, it was determined during regular quality control testing that the vacutainers used in the blood metal analysis were contaminated with manganese. A correction factor of 14 nmol/L was applied to all blood manganese results.

The methods used in the analysis of the environmental chemicals, creatinine, and lipids are described below.

5.1 METALS IN BLOOD

Blood samples were diluted in a basic solution containing octylphenol ethoxylate and ammonia. They were analyzed for total arsenic, cadmium, copper, lead, manganese, total mercury, molybdenum, nickel, selenium, uranium, and zinc by inductively coupled plasma mass spectrometry (ICP-MS), Perkin Elmer Sciex, Elan DRC II (M-572). Matrix matched calibration was performed using blood from a non-exposed individual (INSPQ, 2009a).

5.2 INORGANIC MERCURY IN BLOOD

Blood was digested in a water bath at 80°C with an equal volume of concentrated nitric acid. Inorganic mercury was analyzed by cold vapour atomic absorption spectrometry using a mercury monitor (Model 100 from Pharmacia). An aliquot of the digest was then introduced in the system's reaction chamber containing a reducing solution of stannous chloride. The mercury vapour was generated and detected. Aqueous calibration was performed (INSPQ, 2009b).

5.3 METALS IN URINE

Urine samples were diluted in dilute nitric acid (0.5%) and analyzed for antimony, total arsenic, cadmium, copper, lead, manganese, molybdenum, nickel, selenium, uranium, vanadium, and zinc by ICP-MS, Elan DRC II (M-571). Matrix matched calibration was performed using urine from non-exposed individuals (INSPQ, 2009c).

5.4 INORGANIC MERCURY IN URINE

Following an acid mineralization, the resulting solution was diluted and analyzed on the Flow Injection Mercury System (FIMS) module from Perkin Elmer (M-568) using cold vapour atomic absorption spectrometry. Ionized mercury was reduced to metallic mercury by the action of tin chloride. The volatile mercury formed was detected in the UV/VIS range (INSPQ, 2009d).

5.5 ORGANOCHLORINES, POLYCHLORINATED BIPHENYLS (PCBS) AND POLYBROMINATED FLAME RETARDANTS (PBDES) IN PLASMA

Plasma samples were enriched with internal standards and denatured with formic acid. Organohalogenated compounds, including PCB 28, PCB 52, PCB 66, PCB 74, PCB 99, PCB 101, PCB 105, PCB 118, PCB 128, PCB 138, PCB 146, PCB 153, PCB 156, PCB 163, PCB 167, PCB 170, PCB 178, PCB 180, PCB 183, PCB 187, PCB 194, PCB 201, PCB 203, PCB 206, aldrin, α-chlordane, γ-chlordane, *cis*-nonachlor, *trans*-nonachlor, oxychlordane, β-HCH, γ-HCH, *p,p'*-DDE, *p,p'*-DDT, hexachlorobenzene, mirex, toxaphene parlar 26, toxaphene parlar 50, PBB 153, PBDE 15, PBDE 17, PBDE 25, PBDE 28, PBDE 33, PBDE 47, PBDE 99, PBDE 100, and PBDE 153, were automatically extracted from the aqueous matrix using solid phase separation. Extracts were cleaned up on florisil columns to be analyzed by gas chromatograph (Agilent 6890) coupled to an electron capture detector (ECD) (Agilent G2397A) and mass spectrometry detector (Agilent 5973 Network) with Agilent MSD Chem software. Ions generated were measured after negative chemical ionization. Analyte concentrations were evaluated by consideration of the per cent recovery of labelled internal standards. The ECD served to verify the detection limits for PCB congeners 28 and 52 (INSPQ, 2009e).

Aroclor 1260 was calculated by INSPQ based on the concentration of PCB 153 and PCB 138 as per $C_{\text{Aroclor 1260}} = (C_{\text{PCB 153}} + C_{\text{PCB 138}}) \times 5.2$ (NIOSH, 1997; Patterson, 1991).

Average contamination in the laboratory blanks was subtracted from each sample for hexachlorobenzene, PBDE 47 and PBDE 99. Contamination varied depending on how well the source of contamination was controlled during the laboratory analysis (INSPQ, 2010).

5.6 PERFLUORINATED COMPOUNDS IN PLASMA

Perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS) were extracted with methyl-tert butyl ether in forming an ion pair with tetrabutylammonium hydrogen sulfate. Extracts were evaporated to dryness and dissolved in 200 µL of the mobile phase. They were analyzed by Waters Acquity Ultra Performance Liquid Chromatography (UPLC) coupled to Waters Quattro Premier XE mass spectrometer (MS) and Waters MassLynx software (MS), E-453, operated in the multiple reaction monitoring (MRM) mode with an "electrospray" ion source in the negative mode (INSPQ, 2009f).

5.7 BISPHENOL A IN URINE

Urine samples were thawed at 4°C overnight and shaken vigorously. Samples were stored at room temperature during pipetting, then immediately refrozen. Samples underwent multiple freeze-thaw cycles; 77%, 22%, and 0.8% underwent one, two and three freeze-thaw cycles respectively. 100 µL of urine was fortified with $^{13}C_{12}$-BPA and buffered to a pH 5. Samples were hydrolyzed with β-glucuronidase for three hours at 37°C, then derivatized with pentafluorobenzyl bromide at 70°C for 2 hours. The derivatized products were extracted with a mixture of dichloromethane-hexane. Evaporated extracts were re-dissolved and analyzed by gas chromatography (Agilent 6890 or 7890) coupled to tandem mass spectrometry detector (Waters Quattro Micro-GC), operating in MRM mode following negative chemical ionization (NCI). The free and hydrolysed forms of BPA were measured together by this procedure. Special precautions were taken to minimize BPA contamination throughout the laboratory analysis. Contamination in the laboratory blanks (deionized water, hydrolyzed and derivatized) was subtracted from each analytical sequence. BPA in the laboratory blanks averaged 0.41 µg/L and ranged from 0.08 to 1.27 µg/L (INSPQ, 2009g; 2010).

5.8 ORGANOPHOSPHATE METABOLITES, 2,4-DICHLORPHENOXYACETIC ACID (2,4-D) AND 2,4-DICHLOROPHENOL (2,4-DCP) IN URINE

Urinary metabolites of diethylphosphate (DEP), dimethylphosphate (DMP), diethylthiophosphate (DETP), dimethylthiophosphate (DMTP), diethyldithiophosphate (DEDTP), dimethyldithiophosphate (DMDTP), 2,4-dichlorophenol, and 2,4-dichlorophenoxyacetic acid were hydrolyzed in β-glucuronidase enzyme. The samples were then derivatized with pentafluorobenzyl bromide at 70°C for 2 hours. The derivatized products were extracted with a mixture of dichloromethane-hexane. Evaporated extracts were re-dissolved and analyzed by GC-MS or GC-MS-MS. The GC-MS method employed gas chromatograph (Agilent 6890) coupled to mass spectrometry detector (Agilent MSD-5973 N or Agilent MSD-5975N), with Agilent Chemstation software operated in the single ion monitoring (SIM) mode following either negative chemical ionization (NCI) or electronic impact (EI). The GC-MS-MS method employed gas chromatography (Agilent 6890 or 7890) coupled to tandem mass spectrometry detector (Waters Quattro Micro-GC) with Waters Masslynx software, operating in MRM mode following NCI (INSPQ, 2009g; 2009h).

5.9 PYRETHROID METABOLITES IN URINE

Urinary metabolites were hydrolyzed in β-glucuronidase enzyme. The samples were then acidified and extracted with hexane. Extracts were derivatized and extracted a second time with a mixture of isooctane-hexane. Evaporated extracts were dissolved in hexane and analyzed by gas chromatograph (Agilent 6890 N) coupled to a mass spectrometry detector (Agilent 5973 N) with Agilent MSD Chem software operated in the single ion monitoring (SIM) mode following negative chemical ionization (INSPQ, 2009i).

5.10 COTININE IN URINE

Cotinine was recovered by solid-phase extraction in a 96 well plate format on a Perkin-Elmer JANUS© automated robotic workstation (C-550). Deuterated cotinine was used as the internal standard. The extract was then re-dissolved into 250 μL of mobile phase, and 10 μL was injected into the Waters Acquity Ultra Performance Liquid Chromatography (UPLC) coupled to Waters Quattro Premier XE tandem mass spectrometer (MS) and Waters Masslynx software, operated in the MRM mode with an ion source in "positive electrospray" (INSPQ, 2009j).

5.11 URINE CREATININE

Creatinine was measured using the colorimetric end-point Jaffe method. An alkaline solution of sodium picrate reacts with creatinine to form a red Janovski complex using Microgenics DRI "Creatinine-Detect" reagents (#917). The absorbance was read at 505 nm on a Hitachi 917 chemistry autoanalyzer (C-530) (INSPQ, 2009k).

5.12 SERUM LIPIDS

Triglycerides and total cholesterol were measured by enzymatic methods (Health Canada, 2009a; 2009b). Triglycerides were measured using the VITROS TRIG Slide method based on the procedure described by Spayd et al., (1978) and total cholesterol was measured using the VITROS CHOL Slide method based on the procedure proposed by Allain et al., (1974).

STATISTICAL DATA ANALYSIS

6

Descriptive statistics on the concentration of environmental chemicals in blood and urine of Canadians, aged 6–79 years, were generated using the Statistical Analysis System (SAS) software (SAS Institute Inc., 2002-2003) and the SUDAAN (SUDAAN Release 10.0, 2008) statistical software package.

The CHMS is a sample survey, which means that the respondents "represent" many other Canadians not included in the survey. In order that the results of the survey are representative of the entire population, rather than the sample itself, sample weights were generated by Statistics Canada and incorporated into all estimates presented in this report (e.g., geometric means). Sample weights are used to adjust for the unequal probability of selection into the survey, as well as non-response. Further, to account for the complex survey design of the CHMS, the set of bootstrap weights included with the dataset was used to estimate the 95% confidence intervals for all means and percentiles (Rao et al., 1992; Rust & Rao, 1996).

For each chemical measured, data tables are presented, which include the sample size (*n*), percentage of results that fall below the limit of detection (% <LOD), arithmetic mean (AM), geometric mean (GM), the 10th, 25th, 50th, 75th, 90th and 95th percentiles and associated 95% confidence intervals (95%CI). Three steps were involved in the calculation of the GM and associated 95% CIs. First, the log of each variable was calculated. Second, the mean and 95% CIs for the log transformed variables were calculated using bootstrap weights. Finally, the GM and associated 95% CIs were calculated by taking the antilog of the log transformed mean and associated 95% CIs.

For each chemical, results are presented for the total population as well as by age group and gender. The first cycle of the CHMS was designed to produce national level estimates; as such, site level data is not presented. Measurements that fell below the limit of detection (LOD) for the laboratory analytical method were assigned a value equal to half the LOD. If the proportion of results below the LOD was greater than 40%, geometric and arithmetic means were not calculated. Percentile estimates that are less than the LOD are reported as "< LOD." Appendix B contains a table of LOD values for each chemical. For ease of comparison of data in this report with results from other studies reported in different units, a table of conversion factors is provided in Appendix C.

Chemicals measured in whole blood and plasma are presented as weight of chemical per volume of whole blood or plasma (μg chemical/L blood or plasma, or dL blood in the case of lead). Lipophilic chemicals (i.e., chemicals that accumulate in lipids) measured in plasma, including the organochlorines, PCBs and PBDEs, are presented as weight of chemical per kilogram of total lipid (μg chemical/kg lipid). Lipophilic chemicals concentrate in lipids in the body, including lipids in plasma and serum. Concentrations of these chemicals are reported relative to lipids to reflect the amount of these chemicals that are stored in body fat. Total lipids (g/l) were estimated using the formula:

> Total Lipids (g/L) = 2.27 X total cholesterol (g/L) + triglycerides (g/L) + 0.623
> (Phillips et al., 1989; Bernert et al., 2007; Bergonzi et al., 2009).

If a respondent's total cholesterol and/or triglycerides value was missing or <LOD, then the estimate of that respondent's lipid adjusted chemical was also set to missing.

Ideally, the lipids and environmental chemicals would be measured in the same matrix (e.g., plasma) at the same laboratory. However, due to logistical constraints, the environmental chemicals were measured in plasma at INSPQ and lipids (total cholesterol and triglycerides) were measured in serum by the Health Canada Nutrition Laboratory. Several studies have investigated the difference between lipid measurements in plasma or serum and almost all found plasma lipid levels to be slightly lower than serum lipid levels; however, the magnitude of this effect varied considerably among the studies from 1.3% to 6% (Grande et al., 1964; Lab Methods Committee, 1977; Cloey et al., 1990; Wickus & Dukerschein, 1992; Beheshti et al., 1994). In this report, serum lipid levels were not converted to plasma equivalent levels by applying a conversion factor, as these would not necessarily improve the accuracy of the final lipid-adjusted chemical concentrations, when taking into consideration other sources of variability in the measurements of lipids (e.g., inter- and intra-laboratory analytical variability). Variability in lipid measurements can be as great as 10%–15% among laboratories (INSPQ, 2008). Despite these considerations, the reported values for the lipid adjusted environmental chemicals might be underestimated due to the plasma-serum lipid difference. Further investigation of a potential systematic bias due to plasma-serum lipid differences may be warranted.

For urine measurements, concentrations are presented as weight of chemical per volume of urine (µg chemical/L urine) and adjusted for urinary creatinine (µg chemical/g creatinine). Urinary creatinine is a chemical by-product generated from muscle metabolism and is frequently used to adjust for urine concentration (or dilution) in spot urine samples because its production and excretion are relatively constant over 24 hours due to homeostatic controls (Boeniger et al., 1993; Barr et al., 2005; Pearson et al., 2009). If the chemical measured behaves similarly to creatinine in the kidney, it will be filtered at the same rate, thus expressing the chemical per gram of creatinine helps correct for the effect of urinary dilution as well as some differences in renal function and lean body mass (Barr et al., 2005; Pearson et al., 2009; CDC, 2009). Creatinine is primarily excreted by glomerular filtration in the kidney, and as such, creatinine adjustment may not be appropriate for compounds that are excreted primarily by tubular secretion in the kidney (Teass et al., 2003; Barr et al., 2005). Where urinary creatinine values were missing or <LOD, the estimate of that respondent's creatinine-adjusted chemical was also set to missing.

Descriptive statistics are presented for creatinine (mg/dL) in Appendix D, which include the sample size (*n*), percentage of results that fall below the limit of detection (% <LOD), arithmetic mean (AM), geometric mean (GM), the 10th, 25th, 50th, 75th, 90th and 95th percentiles, and associated 95% confidence intervals (CI), for the total population as well as by age group and gender. Measurements that fell below the limit of detection (LOD) for the laboratory analytical method were assigned a value equal to half the LOD.

Under the *Statistics Act*, Statistics Canada is required to ensure respondent confidentiality. Therefore, estimates based on a small number of respondents are suppressed. Following suppression rules for the CHMS, any estimate based on fewer than 10 respondents is suppressed in this report. To avoid suppression, estimates at the 95th percentile require at least 200 respondents; estimates at the 90th and 10th percentiles require at least 100 respondents; estimates at the 75th and 25th percentiles require at least 40 respondents; estimates at the 50th percentile require at least 20 respondents; and, estimates of the arithmetic and geometric means require at least 10 respondents.

Further details on the sample weights and data analysis are available in the *Canadian Health Measures Survey (CHMS) Data User Guide: Cycle 1* (Statistics Canada, 2010).

CONSIDERATIONS for INTERPRETING the BIOMONITORING DATA

7

The Canadian Health Measures Survey was designed to provide estimates of environmental chemical concentrations in blood or urine for the Canadian population as a whole. The survey covered approximately 96% of the Canadian population ages 6–79 years; however, the survey was not designed to permit further breakdown of data by collection site. In addition, the CHMS design did not target specific exposure scenarios and consequently, did not select or exclude respondents on the basis of their potential for low or high exposures to environmental chemicals.

Biomonitoring can estimate how much of a chemical is present in a person, but cannot tell you what health effects, if any, may result from that exposure. Our ability to measure environmental chemicals at very low levels has advanced. The presence of a chemical in a person's body does not necessarily mean that it will cause a health effect. Factors such as the dose, the duration and timing of exposure, and the toxicity of the chemical are important to determine whether adverse health effects may occur. For chemicals such as lead or mercury, research studies have provided us with a good understanding of what health risks are associated with different levels in blood. However, for many chemicals, further research is needed to understand the health effects, if any, from different blood or urine concentrations. Furthermore, small amounts of certain chemicals, such as manganese and zinc, are essential for the maintenance of good health, and would be expected to be present in the body. In addition, the way in which a chemical will act in the body will differ among individuals and cannot be predicted with certainty. Certain populations (pregnant women, the elderly, or immuno-compromised people) may be more susceptible to the effects of exposure.

The absence of a chemical does not necessarily mean a person has not been exposed. It may be that the technology is not capable of measuring such a small amount, or that the exposure occurred at an earlier point in time, allowing for the chemical to be eliminated from the person's body before measurement took place.

Biomonitoring cannot tell us the source or route of the exposure. The amount of chemical measured indicates the total amount that enters the body through all routes of exposure (ingestion, inhalation, skin contact) and from all sources (air, water, soil, food, and consumer products). The detection of the chemical may be the result of exposure to a single source or multiple sources. In addition, in most cases biomonitoring cannot distinguish between natural sources and anthropogenic sources. Many chemicals – lead, mercury, cadmium, and arsenic for example – occur naturally in the environment and are also present in anthropogenic products.

With the exception of metals, most of the urine measurements in this survey quantify chemical metabolites. For many chemicals, parent compounds may be broken down (i.e., metabolized) into one or more metabolites. For example, the pyrethroid insecticide cyfluthrin is broken down into several metabolites, including 4-F-3-PBA, *cis*-DCCA, and *trans*-DCCA. Some metabolites are specific to one parent compound, while others are common to several parent compounds. Several urinary metabolites are also environmental metabolites (e.g., dialkyl phosphate metabolites) and their presence in urine does not necessarily mean that an exposure to the parent chemical has occurred; rather exposure could be to the metabolite itself in media such as food, water, or air.

Factors that contribute to measured blood and urine levels include the quantity entering the body through all routes of exposure, absorption rates, distribution to various tissues in the body, metabolism, and excretion of the chemical and/or its metabolites from the body. These processes are dependent on both the characteristics of the chemical, including lipophilicity, pH, and particle size, and the characteristics of the individual, such as age, diet, health status, and race (Teass et al., 2003). For these reasons, the way in which a chemical will act in the body will differ among individuals and cannot be predicted with certainty.

This report does not examine trends over time as this is the first survey of this kind conducted in Canada. Results from future cycles of CHMS will be compared to the baseline data from Cycle 1 in order to examine trends in Canadians' exposures to selected environmental chemicals.

More in-depth statistical analysis of the CHMS biomonitoring data, including exploring relationships among environmental chemicals, other physical measures, and self-reported information are beyond the scope of this report and may be performed in the future. The Canadian Health Measures Survey data are being made available to scientists through Statistics Canada's Research Data Centres located across the country and will be a resource for additional scientific analysis.

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8.1 METALS AND TRACE ELEMENTS

8.1.1 Antimony (CASRN 7440-36-0)

Antimony (Sb) is a naturally occurring element that comprises a small fraction of the Earth's crust. It is classified as a metalloid, exhibiting both metallic and non-metallic characteristics. It can exist as an uncombined metal as well as in various oxidation states (-3, 0, +3, +5) and forms (ATSDR, 1992).

Antimony is released into the environment primarily through industrial processes. It may enter the aquatic environment by way of effluents from mining and manufacturing operations, as well as through industrial and municipal leachate discharges, and it is released into the air as stack dust from industrial sources, such as coal-fired power plants, inorganic chemical plants, and metal smelters (Health Canada, 1997). However, it is also found in the environment naturally due to natural weathering of rocks, runoff from soils, emissions from volcanic eruptions, sea spray, and forest fires. Antimony can be obtained from mining or produced from smelting and refining of scrap metals (ATSDR, 1992; Health Canada, 1997). Antimony is used in the production of semi-conductors, infrared detectors, and diodes; as a component in alloys for batteries, cable sheathing, plumbing solder, ammunition and fireworks, flame retardant and anti-friction materials; and as an additive in paint pigments, glass, and ceramic products (Health Canada, 1997; NTP, 2005; ATSDR, 1992). Some forms of antimony are used in pharmaceutical products or to induce vomiting following poisonings (WHO, 2003).

Canadians are exposed to antimony mainly from ingestion of food but also to some extent from water, air, dust, or direct dermal contact with consumer products containing antimony (EURAR, 2008). Concentrations of antimony in meat, freshwater fish, poultry, cereals, fruit, and vegetables appear to range from about 1 to 10 ng/g wet weight; significantly higher levels have been measured in marine organisms (Health Canada, 1997). However, the amount of antimony present in the body is generally low for those not exposed occupationally. Antimony is most commonly measured in blood and urine and this measurement is reflective of exposure to antimony and antimony-related compounds, such as antimony oxide (ATSDR, 1992). An elimination half-life of approximately 95 hours has been estimated after occupational exposures (Kentner et al., 1995). The absorption, distribution, and excretion of antimony depend on both the route of administration and its oxidation state. After inhalation, tissue distribution studies show that the trivalent form accumulates more rapidly than the pentavalent form in the liver, whereas pentavalent antimony is found preferentially in the skeleton. Following ingestion in animals, liver, kidney, bone, lung, spleen, and thyroid are the major sites of accumulation outside the gastrointestinal tract (Health Canada, 1997). In humans, urine accounts for 1.2–3.6 µg of daily antimony excretion. Approximately 0.3–0.9 µg per day (µg/day) is excreted in feces, and less than 1 µg/day is excreted by other routes (Health Canada, 1997). Pentavalent antimony tends to be more readily excreted in the urine than the trivalent form (Elinder & Friberg, 1986).

The low levels of antimony to which the general population is exposed are not expected to cause any adverse health effects (ATSDR, 1992). Chronic occupational exposure to lower doses of antimony compounds is primarily associated with myocardial effects (Health Canada, 1997). Chronic occupational exposure to antimony via inhalation causes damage to the lungs, known as "antimony pneumoconiosis," involving airway obstruction, bronchospasm, and hyperinflation, as well as respiratory irritation and interstitial inflammation. These effects are believed to be primarily due to physiological responses to antimony dust accumulating within the respiratory tract (ATSDR, 1992).

Health Canada and Environment Canada are jointly reviewing and assessing chemical substances as part of the Chemicals Management Plan under the *Canadian Environmental Protection Act, 1999*. Antimony oxide (CAS 1309-64-4) was identified as a high-priority substance under the Chemicals Management Plan, and a draft screening assessment was published in March 2010 (Government of Canada, 2009; Environment Canada and Health Canada, 2010). The proposed conclusion of the Government of Canada's draft screening assessment is that antimony oxide is not of concern to the environment or to human health at current levels of exposure (Environment Canada & Health Canada, 2010). The International Agency for Research on Cancer (IARC) has classified antimony trioxide as Group 2B (a possible human carcinogen) and antimony trisulphide as Group 3 (not classifiable as to its carcinogenicity to humans) (IARC, 1999). The European Commission has classified antimony trioxide as a Category 3 carcinogenic substance (causes concern for humans owing to possible carcinogenic effects) with "limited evidence for a carcinogenic effect" (EURAR, 2008; ESIS, 2009).

Health Canada (1997) has established a tolerable daily intake of 0.2 µg/kg body weight/day for antimony. Chronic oral exposure to this dose is not expected to lead to significant adverse health effects. A Guideline for Canadian Drinking Water Quality of 0.006 mg/L (6 µg/L) has been established, considering both toxicity and analytical capabilities (Health Canada, 1997).

In a study carried out in 2001 in the region of Québec City, on 500 participants aged 18–65, the 90th percentile value of antimony in urine was 0.28 µg/L. The geometric mean and 90th percentile values of antimony in blood were 5.40 µg/L and 6.22 µg/L, respectively (INSPQ, 2004).

Antimony was measured in the urine of all Canadian Health Measures Survey participants aged 6–79 years and is presented as µg/L urine and µg/g creatinine (Tables 8.1.1a, 8.1.1b). Finding a measurable amount of antimony in urine is an indicator of exposure to antimony or antimony-related compounds and does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for urinary levels of antimony in the Canadian population.

Table 8.1.1a

Antimony – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5492	22.40	0.08 0.06 - 0.09	0.04 0.04 - 0.05	<LOD	0.03 0.02 - 0.03	0.05 0.05 - 0.05	0.08 0.07 - 0.08	0.13 0.12 - 0.14	0.18 0.17 - 0.20
6–11	1034	17.99	0.07 0.06 - 0.08	0.05 0.05 - 0.05	<LOD	0.03 0.03 - 0.04	0.06 0.05 - 0.06	0.08 0.08 - 0.09	0.13 0.10 - 0.16	0.18 0.14 - 0.21
12–19	983	12.92	0.09 0.07 - 0.11	0.06 0.05 - 0.07	<LOD	0.04 0.03 - 0.04	0.07 0.06 - 0.07	0.10 0.09 - 0.11	0.15 0.13 - 0.17	0.20 0.17 - 0.23
20–39	1169	25.66	0.09 0.05 - 0.12	0.04 0.04 - 0.05	<LOD	0.02 <LOD - 0.03	0.05 0.04 - 0.05	0.08 0.07 - 0.09	0.13 0.11 - 0.15	0.19 0.15 - 0.23
40–59	1223	27.80	0.07 0.05 - 0.09	0.04 0.04 - 0.04	<LOD	<LOD	0.05 0.04 - 0.05	0.07 0.07 - 0.08	0.14 0.12 - 0.15	0.18 0.16 - 0.21
60–79	1083	25.58	0.06 0.05 - 0.06	0.04 0.04 - 0.04	<LOD	<LOD	0.04 0.04 - 0.04	0.07 0.06 - 0.07	0.11 0.10 - 0.12	0.14 0.12 - 0.16
Males										
Total, age 6–79	2662	15.63	0.09 0.08 - 0.10	0.05 0.05 - 0.06	<LOD	0.03 0.03 - 0.03	0.06 0.05 - 0.06	0.09 0.08 - 0.10	0.14 0.13 - 0.16	0.20 0.17 - 0.22
6–11	524	14.12	0.08 0.06 - 0.09	0.05 0.04 - 0.06	<LOD	0.03 0.03 - 0.04	0.06 0.05 - 0.06	0.09 0.07 - 0.10	0.14 0.09 - 0.19	0.18 0.13 - 0.23
12–19	505	8.51	0.10 0.07 - 0.14	0.07 0.06 - 0.07	0.03 0.02 - 0.03	0.04 0.04 - 0.05	0.07 0.06 - 0.08	0.10 0.09 - 0.12	0.16 0.13 - 0.19	0.21 0.14 - 0.27
20–39	514	18.68	0.08 0.07 - 0.10	0.05 0.04 - 0.06	<LOD	0.03 0.02 - 0.03	0.05 0.05 - 0.06	0.09 0.08 - 0.11	0.14 0.11 - 0.18	0.20 0.15 - 0.25
40–59	578	18.34	0.10 0.06 - 0.14	0.05 0.05 - 0.06	<LOD	0.03 0.03 - 0.04	0.05 0.05 - 0.06	0.09 0.08 - 0.10	0.15 0.13 - 0.18	0.21 0.15 - 0.26
60–79	541	17.93	0.07 0.06 - 0.08	0.05 0.04 - 0.05	<LOD	0.03 0.03 - 0.03	0.05 0.04 - 0.05	0.08 0.07 - 0.09	0.12 0.11 - 0.13	0.16 0.12 - 0.20
Females										
Total, age 6–79	2830	28.76	0.06 0.04 - 0.08	0.04 0.03 - 0.04	<LOD	<LOD	0.04 0.04 - 0.04	0.07 0.06 - 0.07	0.11 0.10 - 0.13	0.17 0.14 - 0.19
6–11	510	21.96	0.06 0.06 - 0.07	0.05 0.04 - 0.05	<LOD	0.03 0.02 - 0.04	0.05 0.05 - 0.06	0.08 0.07 - 0.09	0.12 0.11 - 0.13	0.17 0.13 - 0.21
12–19	478	17.57	0.07 0.06 - 0.08	0.05 0.05 - 0.06	<LOD	0.04 0.03 - 0.04	0.06 0.06 - 0.07	0.09 0.08 - 0.11	0.15 0.12 - 0.18	0.20 0.15 - 0.24
20–39	655	31.15	0.09 0.02 - 0.15	0.04 0.04 - 0.04	<LOD	<LOD	0.04 0.04 - 0.05	0.07 0.06 - 0.08	0.11 0.09 - 0.13	0.18 0.11 - 0.26
40–59	645	36.28	0.05 0.04 - 0.06	0.03 0.03 - 0.04	<LOD	<LOD	0.03 0.03 - 0.04	0.06 0.05 - 0.07	0.11 0.08 - 0.14	0.15 0.13 - 0.18
60–79	542	33.21	0.04 0.04 - 0.05	0.03 0.03 - 0.03	<LOD	<LOD	0.03 0.03 - 0.04	0.05 0.05 - 0.06	0.09 0.08 - 0.11	0.12 0.10 - 0.14

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.1b

Antimony (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5479	22.45	0.08 0.07 - 0.09	0.05 0.05 - 0.06	<LOD	0.04 0.03 - 0.04	0.05 0.05 - 0.05	0.07 0.07 - 0.08	0.12 0.10 - 0.13	0.16 0.14 - 0.18
6–11	1031	18.04	0.09 0.09 - 0.10	0.08 0.07 - 0.08	<LOD	0.05 0.05 - 0.05	0.07 0.07 - 0.08	0.11 0.10 - 0.12	0.15 0.13 - 0.18	0.22 0.16 - 0.28
12–19	982	12.93	0.07 0.05 - 0.08	0.05 0.05 - 0.06	<LOD	0.04 0.03 - 0.04	0.05 0.05 - 0.05	0.07 0.06 - 0.08	0.10 0.09 - 0.11	0.12 0.10 - 0.15
20–39	1165	25.75	0.08 0.05 - 0.11	0.05 0.05 - 0.05	<LOD	0.03 <LOD - 0.03	0.05 0.05 - 0.05	0.07 0.06 - 0.08	0.12 0.10 - 0.13	0.17 0.13 - 0.20
40–59	1218	27.91	0.08 0.06 - 0.09	0.05 0.05 - 0.06	<LOD	<LOD	0.05 0.05 - 0.05	0.07 0.07 - 0.08	0.12 0.10 - 0.15	0.17 0.15 - 0.19
60–79	1083	25.58	0.07 0.06 - 0.07	0.05 0.05 - 0.06	<LOD	<LOD	0.05 0.05 - 0.05	0.07 0.07 - 0.08	0.11 0.10 - 0.12	0.14 0.13 - 0.16
Males										
Total, age 6–79	2653	15.68	0.08 0.07 - 0.09	0.05 0.05 - 0.05	<LOD	0.03 0.03 - 0.04	0.05 0.05 - 0.05	0.07 0.07 - 0.08	0.11 0.10 - 0.13	0.16 0.13 - 0.19
6–11	522	14.18	0.10 0.09 - 0.11	0.08 0.08 - 0.09	<LOD	0.05 0.05 - 0.06	0.08 0.07 - 0.08	0.11 0.10 - 0.12	0.16 0.12 - 0.20	0.24 0.11 - 0.36
12–19	504	8.53	0.07 0.05 - 0.10	0.06 0.05 - 0.06	0.03 0.03 - 0.03	0.04 0.04 - 0.04	0.06 0.05 - 0.06	0.07 0.07 - 0.08	0.10 0.08 - 0.11	0.12 0.10 - 0.15
20–39	512	18.75	0.07 0.06 - 0.07	0.05 0.04 - 0.05	<LOD	0.03 0.03 - 0.03	0.04 0.04 - 0.05	0.07 0.06 - 0.08	0.12 0.10 - 0.13	0.16 0.12 - 0.21
40–59	574	18.47	0.08 0.05 - 0.11	0.05 0.05 - 0.06	<LOD	0.03 0.03 - 0.04	0.05 0.05 - 0.06	0.07 0.06 - 0.08	0.10 0.08 - 0.13	0.16 0.11 - 0.21
60–79	541	17.93	0.06 0.06 - 0.07	0.05 0.05 - 0.05	<LOD	0.03 0.03 - 0.04	0.05 0.04 - 0.05	0.07 0.06 - 0.07	0.10 0.09 - 0.12	0.14 0.11 - 0.16
Females										
Total, age 6–79	2826	28.80	0.08 0.06 - 0.10	0.06 0.05 - 0.06	<LOD	<LOD	0.05 0.05 - 0.06	0.07 0.07 - 0.08	0.12 0.10 - 0.14	0.17 0.14 - 0.20
6–11	509	22.00	0.09 0.08 - 0.10	0.07 0.07 - 0.08	<LOD	0.05 0.05 - 0.06	0.07 0.07 - 0.07	0.10 0.08 - 0.11	0.14 0.12 - 0.17	0.19 0.15 - 0.23
12–19	478	17.57	0.06 0.05 - 0.07	0.05 0.04 - 0.05	<LOD	0.03 0.03 - 0.04	0.05 0.04 - 0.05	0.06 0.05 - 0.07	0.09 0.08 - 0.11	0.12 0.05 - 0.19
20–39	653	31.24	0.09 0.04 - 0.14	0.05 0.05 - 0.06	<LOD	<LOD	0.05 0.05 - 0.05	0.07 0.07 - 0.08	0.11 0.09 - 0.14	0.17 0.09 - 0.24
40–59	644	36.34	0.07 0.06 - 0.08	0.06 0.05 - 0.06	<LOD	<LOD	0.05 0.05 - 0.06	0.07 0.06 - 0.08	0.13 0.11 - 0.16	0.17 0.14 - 0.20
60–79	542	33.21	0.07 0.06 - 0.08	0.06 0.05 - 0.06	<LOD	<LOD	0.06 0.05 - 0.06	0.08 0.07 - 0.09	0.11 0.10 - 0.12	0.15 0.12 - 0.17

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.1.2 Arsenic (CASRN 7440-38-2)

Arsenic (As) is a naturally occurring element that comprises a small fraction of the Earth's crust (ATSDR, 2007). It is classified as a metalloid, exhibiting properties of both a metal and a non-metal. Arsenic has oxidation states of -3, 0, +3, and +5, and is commonly found as an inorganic sulphide complexed with other metals (CCME, 1997). Arsenic also forms stable organic compounds in its trivalent (+3) and pentavalent (+5) states.

The primary anthropogenic sources of arsenic released to the environment are the smelting of metal ores, the use of arsenical pesticides, and the burning of fossil fuels. Arsenic may enter lakes, rivers, or groundwater naturally, when mineral deposits or rocks containing arsenic dissolve. In Canada, gold ores are the primary anthropogenic source of arsenic (Environment Canada & Health Canada, 1993). Arsenic is used in the manufacture of transistors, lasers, and semi-conductors, and in the processing of glass, pigments, textiles, paper, metal adhesives, ceramics, wood preservatives, ammunition, and explosives. Historical uses of arsenic include application of lead arsenate as a pesticide in apple orchards and vineyards, and arsenic trioxide as a herbicide (Health Canada, 2006; ATSDR, 2007). Chromated copper arsenate was formerly used as a wood preservative in residential construction projects such as playground structures and decks; however, it is now used only for industrial purposes and for domestic wood foundations (PMRA, 2005).

The public is exposed to arsenic in food, drinking water, soil, and ambient air, with food (particularly meat and fish) representing the major source of intake (Environment Canada & Health Canada, 1993). Exposure may also arise from indoor house dust, as levels in dust can exceed levels in soil (Rasmussen et al., 2001). Although shellfish and marine species have been found to bioconcentrate arsenic, it is not biomagnified through the food chain (ATSDR, 2007). Exposure to arsenic may be elevated in populations residing in the vicinity of industrial and geological sources. Arsenic can be found in both surface water and groundwater sources, with levels generally higher in groundwater. Drinking water is considered to be the major source of exposure to arsenic only in populations living near a source of arsenic (either a natural geological source or a site of contamination). Smokers are also exposed to arsenic in cigarettes, although it is considered to be of minor importance for arsenic absorption (Schneider & Krivan, 1993).

Arsenic compounds are readily absorbed in the gastrointestinal tract (~45–90%) (Pomroy et al., 1980; Yamauchi et al., 1986). Following oral ingestion, inorganic arsenic appears rapidly in the circulation, where it binds primarily to hemoglobin. Within 24 hours, it is found mainly in the liver, kidneys, lungs, spleen, and skin. Skin, bone, and muscle represent the major storage sites. In cases of chronic exposure, arsenic will preferentially accumulate in tissues rich in keratin and/or sulfhydryl (thiol) groups, such as hair, nails, skin, and other protein-containing tissues (Human Biomonitoring Commission of the German Federal Environmental Agency, 2003). The half-life of inorganic arsenic in humans is estimated to be between two and 40 days (Health Canada, 2006). A considerable portion of inorganic arsenic is eliminated from the body by the rapid urinary excretion of non-methylated arsenic in both trivalent and pentavalent forms and by sequential methylation of arsenic (+3) to monomethylarsonic acid (MMAA) and dimethylarsinic acid (DMAA) in the liver (WHO, 1996).

Measurements of arsenic in urine are useful biological indicators of exposure (ATSDR, 2007). Measurement of urinary arsenic levels is generally accepted as the most reliable indicator of recent arsenic exposure, since arsenic absorbed from the lungs or the gastrointestinal tract is excreted in the urine within one to two days, while arsenic is cleared from blood within a few hours (ATSDR, 2007). Measurements of arsenic in urine have been used to identify recent arsenic ingestion or above-average exposures in populations living near industrial point sources of arsenic. Arsenic levels can also be measured in the blood; however, blood arsenic levels are not as well correlated with drinking water concentrations as are urine arsenic levels (Valentine et al., 1979).

While the majority of assessments on the toxicity of arsenic have concentrated on the inorganic forms, recent studies have highlighted the potential for organic arsenic compounds, in particular the trivalent monomethylated arsenic (MMA^{III}), to also exert adverse health effects (Cohen et al., 2006; Schwedtle et al., 2003). Further research is required to confirm these findings (Health Canada, 2006). Inhalation of inorganic arsenic has been associated with respiratory cancer for workers in smelters and production facilities for arsenical pesticides (Environment Canada & Health Canada, 1993). Chronic ingestion of arsenic has also been associated with non-cancer effects on the skin (Environment Canada & Health Canada, 1993), cardiovascular effects including increased incidence of high blood pressure and circulatory problems, and decreased lung function (ATSDR, 2007).

Health Canada and Environment Canada concluded that current concentrations of inorganic arsenic in Canada may be harmful to the environment and to human health (Environment Canada & Health Canada, 1993). Arsenic is classified as a human carcinogen (Group I) by Health Canada (2006) and other international agencies (IARC, 2004; US EPA, 1998). Health Canada has established a maximum acceptable concentration for arsenic in drinking water of 0.010 mg/L based on the incidence of internal (lung, bladder, and liver) cancers in humans and taking into consideration the ability of currently available technologies to remove arsenic from drinking water (Health Canada, 2006).

In a study carried out in British Columbia to assess the levels of trace elements in 61 non-smoking adults aged 30–65, the geometric mean concentration and 95th percentile of total arsenic in urine were 27.8 μg/g creatinine and 175.5 μg/g creatinine, respectively (Clark et al., 2007). In a separate study carried out in the region of Québec City on 500 adults aged 18–65, the geometric mean and 90th percentile values of total arsenic in urine were 12.73 μg/L and 65.18 μg/L, respectively. The geometric mean and 90th percentile values of arsenic in blood were 0.95 μg/L and 2.82 μg/L, respectively (INSPQ, 2004).

Total arsenic was measured in the blood and urine of all participants aged 6–79 years in the Canadian Health Measures Survey (CHMS) and is presented as μg/L in blood and as both μg/L and μg/g creatinine in urine (Tables 8.1.2a, 8.1.2b, 8.1.2c). Finding a measurable amount of arsenic in blood or urine is an indicator of exposure to arsenic and does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for blood and urinary levels of total arsenic in the Canadian population.

Table 8.1.2a

Arsenic – Arithmetic and geometric means, and selected percentiles of blood concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5319	7.24	1.41 1.11 - 1.72	0.89 0.74 - 1.06	0.31 <LOD - 0.41	0.54 0.42 - 0.66	0.86 0.72 - 1.01	1.48 1.20 - 1.76	2.70 1.94 - 3.46	4.08 2.94 - 5.23
6–11	910	10.77	0.85 0.72 - 0.98	0.59 0.48 - 0.74	<LOD	0.38 0.24 - 0.52	0.66 0.52 - 0.79	0.98 0.84 - 1.12	1.51 1.14 - 1.88	2.16 1.16 - 3.15
12–19	945	10.90	0.89 0.57 - 1.21	0.59 0.46 - 0.75	<LOD	0.38 0.29 - 0.48	0.66 0.50 - 0.81	0.96 0.73 - 1.19	1.51 1.09 - 1.93	1.83 0.99 - 2.66
20–39	1165	6.78	1.28 1.01 - 1.55	0.86 0.72 - 1.04	0.30 <LOD - 0.39	0.54 0.43 - 0.66	0.86 0.71 - 1.01	1.48 1.15 - 1.81	2.45 1.63 - 3.27	3.57 2.50 - 4.64
40–59	1220	4.84	1.63 1.18 - 2.08	0.99 0.81 - 1.20	0.34 <LOD - 0.47	0.60 0.47 - 0.73	0.95 0.79 - 1.11	1.61 1.28 - 1.93	3.04 2.05 - 4.03	4.70 2.48 - 6.93
60–79	1079	4.26	1.77 1.31 - 2.22	1.12 0.91 - 1.38	0.41 0.29 - 0.53	0.63 0.51 - 0.75	1.06 0.82 - 1.31	1.95 1.37 - 2.54	3.56 2.52 - 4.60	5.11 3.51 - 6.71
Males										
Total, age 6–79	2576	6.72	1.43 1.11 - 1.74	0.89 0.75 - 1.06	0.31 <LOD - 0.40	0.54 0.44 - 0.65	0.85 0.70 - 1.00	1.48 1.18 - 1.78	2.72 1.93 - 3.50	3.97 2.76 - 5.17
6–11	459	11.11	0.76 0.56 - 0.97	0.56 0.41 - 0.75	<LOD	0.35 <LOD - 0.51	0.62 0.44 - 0.80	0.92 0.69 - 1.16	1.34 0.77 - 1.91	1.89 1.28 - 2.50
12–19	489	11.66	0.88 0.43 - 1.34	0.58 0.44 - 0.75	<LOD	0.38 0.29 - 0.48	0.64 0.48 - 0.79	0.95 0.66 - 1.24	1.49 1.09 - 1.89	1.66 0.24 - 3.08
20–39	514	4.67	1.22 0.96 - 1.48	0.85 0.70 - 1.03	0.31 0.23 - 0.39	0.55 0.43 - 0.68	0.84 0.69 - 0.99	1.46 1.08 - 1.83	2.25 1.31 - 3.20	3.37 2.11 - 4.62
40–59	577	4.33	1.77 1.20 - 2.34	1.03 0.87 - 1.23	0.39 0.27 - 0.52	0.61 0.50 - 0.73	0.96 0.77 - 1.16	1.62 1.30 - 1.94	3.25 2.38 - 4.12	5.01 2.24 - 7.79
60–79	537	2.98	1.76 1.35 - 2.16	1.16 0.96 - 1.40	0.41 0.31 - 0.52	0.66 0.52 - 0.79	1.13 0.83 - 1.43	1.98 1.42 - 2.54	3.55 2.46 - 4.65	4.97 3.49 - 6.46
Females										
Total, age 6–79	2743	7.73	1.40 1.09 - 1.71	0.88 0.73 - 1.07	0.29 <LOD - 0.41	0.53 0.40 - 0.67	0.89 0.74 - 1.03	1.48 1.21 - 1.76	2.67 1.84 - 3.50	4.19 2.89 - 5.49
6–11	451	10.42	0.94 0.80 - 1.09	0.64 0.54 - 0.75	<LOD	0.40 0.27 - 0.52	0.68 0.56 - 0.81	1.03 0.94 - 1.13	1.65 0.98 - 2.32	3.13 1.71 - 4.55
12–19	456	10.09	0.90 0.65 - 1.14	0.61 0.47 - 0.78	<LOD	0.39 0.27 - 0.50	0.66 0.50 - 0.83	0.96 0.75 - 1.16	1.54 1.07 - 2.00	1.96 1.40 - 2.52
20–39	651	8.45	1.35 0.99 - 1.70	0.88 0.71 - 1.07	0.30 <LOD - 0.41	0.53 0.39 - 0.66	0.88 0.69 - 1.07	1.47 1.17 - 1.78	2.56 1.62 - 3.51	4.00 2.23 - 5.77
40–59	643	5.29	1.49 1.12 - 1.86	0.95 0.75 - 1.20	0.33 <LOD - 0.46	0.57 0.38 - 0.76	0.95 0.78 - 1.11	1.57 1.15 - 1.99	2.83 1.73 - 3.93	4.49 2.52 - 6.46
60–79	542	5.54	1.77 1.22 - 2.33	1.09 0.86 - 1.39	0.40 0.24 - 0.57	0.62 0.50 - 0.73	1.04 0.82 - 1.26	1.90 1.16 - 2.64	3.57 2.26 - 4.87	5.28 2.90 - 7.65

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.2b

Arsenic – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5492	0.18	23.07 17.67 - 28.48	12.00 10.16 - 14.17	3.20 2.90 - 3.49	5.85 5.06 - 6.64	11.67 9.26 - 14.07	23.77 18.59 - 28.95	44.18 36.80 - 51.57	70.63 51.87 - 89.39
6–11	1034	0.10	18.65 13.82 - 23.48	9.66 8.16 - 11.44	2.46 1.83 - 3.08	4.82 3.80 - 5.83	9.63 7.66 - 11.61	18.59 14.85 - 22.33	35.42 28.37 - 42.47	51.31 27.81 - 74.81
12–19	983	0.31	22.58 9.91 - 35.25	11.88 9.96 - 14.16	3.51 2.74 - 4.27	6.61 5.73 - 7.49	11.37 9.05 - 13.68	21.44 15.11 - 27.76	37.40 23.86 - 50.94	55.57 30.29 - 80.86
20–39	1169	0.09	22.47 17.82 - 27.12	12.08 10.44 - 13.99	3.03 2.60 - 3.45	5.86 5.04 - 6.67	12.06 10.17 - 13.94	25.04 17.88 - 32.20	45.11 37.50 - 52.71	66.97 47.15 - 86.79
40–59	1223	0.41	24.99 18.10 - 31.89	12.60 10.45 - 15.19	3.26 2.85 - 3.68	6.08 4.81 - 7.34	12.18 9.07 - 15.29	24.95 19.53 - 30.38	44.94 37.25 - 52.62	77.68 46.76 - 108.61
60–79	1083	0.00	22.59 16.08 - 29.11	11.85 9.30 - 15.10	3.59 3.01 - 4.18	5.66 4.38 - 6.95	11.27 7.34 - 15.20	22.73 16.96 - 28.49	46.02 27.21 - 64.83	72.72 48.74 - 96.69
Males										
Total, age 6–79	2662	0.23	24.73 18.02 - 31.43	13.31 11.08 - 15.99	3.73 3.36 - 4.10	6.82 5.66 - 7.97	12.62 9.39 - 15.85	25.82 19.27 - 32.38	46.92 38.23 - 55.61	73.44 50.40 - 96.49
6–11	524	0.19	18.39 10.30 - 26.49	9.61 7.12 - 12.99	2.48 1.23 - 3.73	5.21 3.72 - 6.70	9.64 7.14 - 12.14	17.67 11.62 - 23.72	33.32 20.80 - 45.83	50.89 26.10 - 75.69
12–19	505	0.40	23.44 2.33 - 44.55	11.79 9.48 - 14.67	3.81 2.99 - 4.62	6.82 6.10 - 7.54	10.90 8.36 - 13.44	20.51 15.23 - 25.78	33.41 20.64 - 46.18	52.73 6.60 - 98.85
20–39	514	0.19	21.68 17.36 - 26.00	13.06 11.09 - 15.39	3.59 2.97 - 4.20	6.13 4.96 - 7.31	12.67 9.79 - 15.55	28.04 18.71 - 37.38	48.54 36.15 - 60.93	66.70 47.65 - 85.75
40–59	578	0.35	29.07 18.93 - 39.22	15.01 11.96 - 18.83	4.17 3.00 - 5.35	7.89 6.21 - 9.58	14.46 9.96 - 18.95	29.87 22.21 - 37.52	47.53 30.65 - 64.41	94.70 48.42 - 140.99
60–79	541	0.00	25.42 16.90 - 33.95	13.65 10.29 - 18.12	3.84 2.84 - 4.85	6.84 4.80 - 8.87	13.61 9.11 - 18.10	25.66 18.97 - 32.35	47.27 21.82 - 72.73	75.45 44.85 - 106.05
Females										
Total, age 6–79	2830	0.14	21.42 16.86 - 25.99	10.81 9.27 - 12.61	2.80 2.36 - 3.24	5.12 4.44 - 5.79	10.81 8.84 - 12.78	21.98 18.07 - 25.88	41.43 33.99 - 48.88	67.50 49.41 - 85.58
6–11	510	0.00	18.92 13.88 - 23.97	9.72 8.21 - 11.50	2.21 1.50 - 2.93	4.42 3.44 - 5.40	9.51 7.13 - 11.90	19.78 16.00 - 23.57	35.89 28.73 - 43.05	52.47 9.29 - 95.66
12–19	478	0.21	21.64 14.38 - 28.90	11.98 9.79 - 14.66	3.08 1.43 - 4.74	5.87 4.09 - 7.65	12.05 9.09 - 15.01	23.59 14.56 - 32.63	42.57 27.61 - 57.53	57.19 37.45 - 76.93
20–39	655	0.00	23.26 16.58 - 29.93	11.17 9.49 - 13.15	2.37 1.73 - 3.00	5.12 3.96 - 6.29	11.48 10.04 - 12.92	22.26 17.17 - 27.35	43.16 33.96 - 52.36	67.61 35.93 - 99.29
40–59	645	0.47	20.95 15.85 - 26.06	10.60 8.97 - 12.53	2.88 2.40 - 3.37	4.68 3.83 - 5.53	9.78 7.30 - 12.26	22.71 18.54 - 26.88	41.24 34.72 - 47.75	70.71 46.91 - 94.51
60–79	542	0.00	20.00 14.69 - 25.30	10.40 8.14 - 13.30	3.24 2.30 - 4.19	5.07 3.95 - 6.19	9.35 6.03 - 12.67	20.05 14.73 - 25.37	38.62 20.18 - 57.07	70.46 46.01 - 94.92

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.2c

Arsenic (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (μg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5479	0.18	25.82 18.00 - 33.65	14.24 11.44 - 17.72	4.74 3.93 - 5.54	7.45 5.93 - 8.97	13.07 10.09 - 16.05	24.43 18.70 - 30.16	46.49 33.74 - 59.24	67.76 45.70 - 89.82
6–11	1031	0.10	25.35 18.41 - 32.29	14.76 12.23 - 17.80	5.41 4.60 - 6.22	7.85 6.15 - 9.55	13.22 10.10 - 16.33	24.51 19.02 - 29.99	42.59 33.60 - 51.58	59.33 15.61 - 103.05
12–19	982	0.31	15.95 7.06 - 24.85	9.82 7.68 - 12.56	3.73 3.09 - 4.36	5.51 4.31 - 6.71	9.25 6.91 - 11.60	16.05 11.49 - 20.60	29.06 19.19 - 38.94	35.75 20.15 - 51.35
20–39	1165	0.09	22.01 16.54 - 27.49	13.35 10.80 - 16.50	4.57 3.84 - 5.30	7.03 5.72 - 8.34	12.52 9.41 - 15.63	23.64 17.84 - 29.45	42.92 30.82 - 55.02	60.29 39.57 - 81.00
40–59	1218	0.41	31.34 17.30 - 45.37	15.72 12.47 - 19.81	5.11 3.72 - 6.51	8.47 6.90 - 10.03	14.26 10.83 - 17.68	25.98 20.79 - 31.17	50.88 32.15 - 69.61	75.15 15.17 - 135.13
60–79	1083	0.00	28.55 20.16 - 36.95	16.57 12.60 - 21.78	5.41 4.41 - 6.42	7.88 5.10 - 10.67	14.86 9.64 - 20.08	29.82 17.51 - 42.13	56.24 39.53 - 72.96	86.85 57.07 - 116.63
Males										
Total, age 6–79	2653	0.23	25.11 15.59 - 34.63	12.85 10.34 - 15.96	4.49 3.68 - 5.29	6.82 5.46 - 8.18	11.50 8.66 - 14.34	22.05 17.14 - 26.96	38.39 25.59 - 51.18	60.03 41.58 - 78.47
6–11	522	0.19	25.11 13.72 - 36.50	14.34 11.30 - 18.20	5.52 4.61 - 6.43	7.43 5.71 - 9.15	12.45 8.43 - 16.47	23.16 16.52 - 29.79	42.80 28.70 - 56.90	56.29 11.90 - 100.69
12–19	504	0.40	16.61 2.63 - 30.60	9.47 7.25 - 12.36	3.47 2.61 - 4.32	5.14 3.70 - 6.57	8.98 6.88 - 11.07	15.78 11.03 - 20.54	29.69 19.13 - 40.24	35.21 20.28 - 50.14
20–39	512	0.20	17.88 13.83 - 21.93	11.73 9.42 - 14.60	4.10 2.91 - 5.29	6.65 5.06 - 8.25	10.82 8.06 - 13.59	21.40 15.96 - 26.83	33.17 23.71 - 42.63	48.48 39.11 - 57.86
40–59	574	0.35	35.23 13.86 - 56.60	14.36 11.27 - 18.29	4.74 3.42 - 6.06	7.56 5.97 - 9.14	12.57 9.04 - 16.11	23.65 18.25 - 29.04	44.13 20.99 - 67.27	70.40 <LOD - 143.82
60–79	541	0.00	24.23 17.40 - 31.06	14.40 11.22 - 18.47	5.15 4.27 - 6.03	7.31 5.58 - 9.05	12.98 8.83 - 17.13	23.80 16.86 - 30.74	47.22 29.09 - 65.36	72.72 41.06 - 104.37
Females										
Total, age 6–79	2826	0.14	26.54 19.77 - 33.30	15.78 12.61 - 19.75	5.07 4.14 - 6.01	8.18 6.45 - 9.92	14.55 11.25 - 17.85	27.31 19.62 - 35.00	50.89 37.06 - 64.72	79.61 53.80 - 105.43
6–11	509	0.00	25.60 18.45 - 32.75	15.20 12.59 - 18.36	5.31 4.08 - 6.54	8.40 6.50 - 10.29	13.73 10.77 - 16.69	25.38 19.15 - 31.61	41.66 31.55 - 51.77	61.26 <LOD - 128.24
12–19	478	0.21	15.24 10.73 - 19.75	10.23 7.89 - 13.26	4.06 3.33 - 4.79	5.74 4.39 - 7.08	9.41 6.51 - 12.31	16.40 11.41 - 21.38	29.06 19.19 - 38.93	38.71 22.74 - 54.67
20–39	653	0.00	26.18 17.98 - 34.39	15.21 12.10 - 19.12	4.88 4.06 - 5.70	7.61 6.31 - 8.90	14.26 11.29 - 17.22	26.96 18.03 - 35.88	48.78 32.70 - 64.87	79.61 42.95 - 116.26
40–59	644	0.47	27.50 19.67 - 35.33	17.19 13.54 - 21.82	5.66 3.78 - 7.55	9.51 6.88 - 12.14	15.95 11.55 - 20.34	28.05 21.82 - 34.27	53.24 37.99 - 68.49	85.99 35.84 - 136.14
60–79	542	0.00	32.53 22.15 - 42.90	18.85 13.83 - 25.70	5.78 4.15 - 7.40	9.32 5.80 - 12.83	17.13 10.20 - 24.07	36.96 23.41 - 50.50	64.77 47.58 - 81.97	95.97 57.56 - 134.39

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.1.3 Cadmium (CASRN 7440-43-9)

Cadmium (Cd) is a naturally occurring soft, silvery white, blue tinged metal. It is among the least abundant trace metals and often occurs in zinc ores. Canadian zinc ores typically contain 0.001–0.067% recoverable cadmium (Environment Canada, 1972). Common forms of cadmium include soluble and insoluble species, which may also be found as particulate matter in the atmosphere (CCME, 1996; ATSDR, 1999).

Most of the cadmium released into the environment is the result of anthropogenic activities; however, cadmium also enters the environment as a result of natural processes, including forest fires, volcanic emissions, and weathering of soil and bedrock. The main sources of cadmium emitted into the atmosphere are from industrial base-metal smelting and refining processes, and combustion processes, such as coal-fired electrical plants and waste incineration where cadmium is released as a by-product (CCME, 1996).

Cadmium is primarily used in manufacture of nickel-cadmium batteries. It is also used in industrial coatings and electroplating, in pigments, and as a plastic stabilizer in PVC plastics. Cadmium is present in metal alloy sheets, wires, rods, solders, and shields for various industrial applications (Environment Canada & Health Canada, 1994). It is frequently an impurity in galvanized pipes and can leach into drinking water (Health Canada, 1986). Cadmium is sometimes used as a pigment in ceramic glazes. In Canada, the leachable cadmium content of glazed ceramics and glassware is regulated under the *Hazardous Products Act* (Health Canada, 2006). The Act also limits the leachable cadmium content of paints and other surface coatings on toys and other products for use by a child in learning or play to 1000 mg/kg (Health Canada, 2009).

Inhalation of cigarette smoke is the major source of cadmium exposure in smokers. The tobacco of one typical Canadian cigarette contains approximately 1 μg of cadmium, of which 6–20% may be transferred in mainstream smoke (Hammond & O'Connor, 2008). Smoking 20 cigarettes per day can therefore result in an additional daily exposure of approximately 1.2–4 μg of cadmium. Non-smokers are primarily exposed to cadmium through food, although occupational exposure can also be a significant source. Cadmium can also be present in drinking water; other minor exposure pathways include inhalation and leaching/releases from consumer products (Environment Canada & Health Canada, 1994; ATSDR, 1999).

Absorption of cadmium in the body depends on the levels of other components of the diet, such as iron, calcium, and protein. The total amount absorbed by humans has been estimated to be between 0.2 and 0.5 μg/day. Absorbed cadmium accumulates mainly in the renal cortex and liver, with concentrations in the renal cortex approximately 5–20 times those in the liver. Only a small proportion of absorbed cadmium is eliminated, mainly in the urine and feces, although small amounts are also eliminated through hair, nails, and sweat. The biological half-life of cadmium has been estimated to be approximately 10–12 years (Amzal et al., 2009; Lauwerys et al., 1994).

Cadmium can be measured in blood, urine, feces, liver, kidney, and hair, among other tissues. Cadmium concentrations in urine best reflect the total body burden of cadmium (i.e., cumulative exposure), although they fluctuate slightly due to recent exposures. American studies indicate that non-smokers have urinary cadmium concentrations of approximately 0.35 µg/g creatinine in the absence of high environmental or occupational exposure (ATSDR, 1999). Concentrations of cadmium in blood reflect both recent and cumulative exposures (CDC, 2005). Typical concentrations in blood are approximately 0.4 to 1 µg/L for non-smokers. Smoking and occupational exposures can elevate blood concentrations (ATSDR, 1999).

Health Canada and Environment Canada concluded that inorganic cadmium compounds are a concern for human health (Environment Canada and Health Canada, 1994). Cadmium and its compounds have been classified as human carcinogens (Group 1) by the International Agency for Research on Cancer (IARC, 1997), with exposure to high levels by inhalation primarily associated with lung cancer. Cadmium is also a respiratory irritant when high concentrations are present in workplace air, and chronic inhalation exposure has been associated with lung effects, including emphysema, and kidney effects.

Oral exposure to high doses of cadmium may cause severe gastrointestinal irritation and kidney effects (ATSDR, 1999). On the basis of health considerations, Health Canada has established a maximum acceptable concentration (MAC) of 0.005 mg/L (5 µg/L) cadmium in drinking water (Health Canada, 1986).

In a study carried out in the region of Québec City on adults aged 18–65, the geometric mean and 90th percentile values of cadmium in urine were 0.54 µg/L and 1.26 µg/L, respectively. The geometric mean and 90th percentile values of cadmium in blood were 0.69 µg/L and 3.43 µg/L, respectively (INSPQ, 2004).

Cadmium was measured in the blood and urine of all participants aged 6–79 years in the Canadian Health Measures Survey and is presented as µg/L in blood and as both µg/L and µg/g creatinine in urine (Tables 8.1.3a, 8.1.3b, 8.1.3c). Finding a measurable amount of cadmium in blood or urine is an indicator of exposure to cadmium and does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for blood and urinary levels of cadmium in the Canadian population.

Table 8.1.3a

Cadmium – Arithmetic and geometric means, and selected percentiles of blood concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5319	2.91	0.77 0.69 - 0.84	0.35 0.32 - 0.38	0.10 0.09 - 0.11	0.15 0.14 - 0.17	0.28 0.25 - 0.30	0.63 0.55 - 0.71	2.42 2.01 - 2.83	3.63 3.14 - 4.12
6–11	910	9.12	0.11 0.10 - 0.13	0.10 0.09 - 0.11	0.05 <LOD - 0.06	0.08 0.07 - 0.08	0.10 0.09 - 0.11	0.14 0.12 - 0.15	0.19 0.16 - 0.22	0.23 0.19 - 0.26
12–19	945	3.92	0.35 0.17 - 0.53	0.17 0.14 - 0.21	0.07 0.05 - 0.09	0.11 0.09 - 0.12	0.15 0.13 - 0.16	0.22 0.19 - 0.24	0.52 0.07 - 0.97	1.45 <LOD - 3.05
20–39	1165	1.55	0.81 0.71 - 0.91	0.35 0.31 - 0.39	0.10 0.09 - 0.12	0.15 0.13 - 0.16	0.24 0.22 - 0.27	0.68 0.43 - 0.93	2.63 2.10 - 3.15	3.43 3.11 - 3.76
40–59	1220	0.90	1.00 0.86 - 1.13	0.49 0.44 - 0.54	0.14 0.12 - 0.16	0.21 0.19 - 0.23	0.37 0.32 - 0.41	1.00 0.71 - 1.28	3.16 2.34 - 3.97	4.21 3.71 - 4.71
60–79	1079	0.56	0.73 0.63 - 0.84	0.45 0.42 - 0.49	0.18 0.17 - 0.19	0.25 0.24 - 0.26	0.39 0.38 - 0.41	0.71 0.60 - 0.83	1.73 1.20 - 2.26	2.76 2.26 - 3.25
Males										
Total, age 6–79	2576	3.34	0.73 0.62 - 0.83	0.31 0.28 - 0.35	0.09 0.08 - 0.10	0.14 0.12 - 0.15	0.23 0.20 - 0.25	0.58 0.44 - 0.73	2.35 1.90 - 2.80	3.48 2.89 - 4.07
6–11	459	9.59	0.11 0.10 - 0.13	0.09 0.08 - 0.10	0.05 <LOD - 0.07	0.07 0.07 - 0.08	0.10 0.09 - 0.11	0.13 0.12 - 0.15	0.19 0.16 - 0.22	0.21 0.16 - 0.27
12–19	489	3.48	0.37 0.14 - 0.60	0.16 0.13 - 0.20	0.06 0.04 - 0.08	0.10 0.08 - 0.12	0.14 0.12 - 0.16	0.21 0.18 - 0.24	0.51 <LOD - 1.18	1.54 <LOD - 3.80
20–39	514	2.14	0.85 0.72 - 0.98	0.33 0.27 - 0.41	0.09 0.06 - 0.11	0.13 0.11 - 0.15	0.21 0.16 - 0.26	0.77 0.39 - 1.14	2.86 2.10 - 3.62	3.63 3.17 - 4.09
40–59	577	1.73	0.88 0.65 - 1.10	0.40 0.33 - 0.49	0.12 0.09 - 0.14	0.18 0.15 - 0.21	0.28 0.24 - 0.31	0.86 0.33 - 1.38	2.83 1.74 - 3.91	3.87 2.84 - 4.91
60–79	537	0.74	0.67 0.53 - 0.81	0.41 0.35 - 0.48	0.16 0.14 - 0.18	0.23 0.21 - 0.24	0.35 0.31 - 0.39	0.66 0.44 - 0.89	1.68 0.96 - 2.41	2.73 1.86 - 3.60
Females										
Total, age 6–79	2743	2.52	0.81 0.72 - 0.89	0.39 0.36 - 0.42	0.11 0.10 - 0.12	0.18 0.16 - 0.20	0.33 0.29 - 0.37	0.65 0.57 - 0.74	2.52 2.06 - 2.98	3.73 3.11 - 4.35
6–11	451	8.65	0.12 0.10 - 0.13	0.10 0.09 - 0.11	0.05 <LOD - 0.07	0.08 0.07 - 0.09	0.11 0.10 - 0.11	0.14 0.12 - 0.15	0.19 0.15 - 0.23	0.23 0.19 - 0.27
12–19	456	4.39	0.33 0.19 - 0.46	0.18 0.15 - 0.22	0.08 0.07 - 0.10	0.11 0.09 - 0.12	0.16 0.13 - 0.18	0.23 0.20 - 0.27	0.56 0.20 - 0.91	1.32 0.05 - 2.59
20–39	651	1.08	0.77 0.63 - 0.90	0.36 0.32 - 0.41	0.11 0.10 - 0.13	0.17 0.14 - 0.19	0.27 0.23 - 0.32	0.63 0.45 - 0.81	2.49 1.93 - 3.05	3.24 2.74 - 3.75
40–59	643	0.16	1.12 0.95 - 1.29	0.58 0.51 - 0.66	0.19 0.16 - 0.22	0.27 0.24 - 0.31	0.44 0.37 - 0.50	1.12 0.66 - 1.58	3.70 2.86 - 4.55	4.43 3.92 - 4.94
60–79	542	0.37	0.79 0.65 - 0.93	0.49 0.44 - 0.56	0.19 0.17 - 0.22	0.28 0.25 - 0.31	0.43 0.37 - 0.48	0.76 0.65 - 0.88	1.77 0.97 - 2.57	2.75 1.90 - 3.59

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.3b

Cadmium – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M.[a] 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5491	9.71	0.55 0.52 - 0.58	0.35 0.32 - 0.38	0.09 <LOD - 0.11	0.20 0.17 - 0.22	0.38 0.35 - 0.41	0.68 0.63 - 0.72	1.16 1.06 - 1.27	1.65 1.54 - 1.75
6–11	1033	14.71	0.31 0.26 - 0.37	0.22 0.19 - 0.26	<LOD	0.13 0.10 - 0.16	0.25 0.21 - 0.29	0.42 0.38 - 0.47	0.59 0.52 - 0.65	0.72 0.60 - 0.85
12–19	983	10.48	0.37 0.32 - 0.42	0.27 0.24 - 0.31	<LOD	0.18 0.15 - 0.21	0.32 0.28 - 0.36	0.48 0.43 - 0.54	0.68 0.58 - 0.78	0.89 0.65 - 1.13
20–39	1169	13.17	0.43 0.39 - 0.47	0.28 0.25 - 0.31	<LOD	0.17 0.14 - 0.20	0.32 0.28 - 0.36	0.54 0.49 - 0.59	0.92 0.83 - 1.01	1.20 1.04 - 1.35
40–59	1223	7.36	0.67 0.62 - 0.72	0.42 0.38 - 0.47	0.11 <LOD - 0.14	0.25 0.21 - 0.28	0.46 0.40 - 0.51	0.81 0.74 - 0.88	1.51 1.35 - 1.68	2.10 1.75 - 2.44
60–79	1083	3.14	0.77 0.69 - 0.85	0.50 0.45 - 0.56	0.14 0.11 - 0.17	0.28 0.24 - 0.32	0.52 0.47 - 0.57	0.99 0.88 - 1.09	1.61 1.41 - 1.81	2.30 1.93 - 2.67
Males										
Total, age 6–79	2661	8.27	0.55 0.51 - 0.59	0.36 0.33 - 0.39	0.10 <LOD - 0.12	0.21 0.19 - 0.23	0.39 0.36 - 0.43	0.69 0.63 - 0.75	1.16 1.05 - 1.28	1.58 1.44 - 1.73
6–11	523	13.00	0.31 0.26 - 0.36	0.23 0.19 - 0.27	<LOD	0.15 0.12 - 0.18	0.26 0.19 - 0.33	0.42 0.37 - 0.48	0.60 0.54 - 0.65	0.71 0.59 - 0.83
12–19	505	8.12	0.35 0.31 - 0.40	0.27 0.24 - 0.31	0.10 <LOD - 0.11	0.20 0.16 - 0.23	0.31 0.27 - 0.35	0.45 0.39 - 0.52	0.62 0.50 - 0.74	0.77 0.55 - 0.99
20–39	514	11.87	0.41 0.36 - 0.45	0.29 0.25 - 0.33	<LOD	0.17 0.14 - 0.21	0.33 0.28 - 0.39	0.54 0.47 - 0.62	0.92 0.82 - 1.02	1.14 0.99 - 1.29
40–59	578	6.57	0.67 0.59 - 0.74	0.44 0.39 - 0.50	0.12 <LOD - 0.15	0.26 0.22 - 0.30	0.49 0.43 - 0.56	0.82 0.71 - 0.92	1.56 1.33 - 1.78	1.94 1.52 - 2.36
60–79	541	2.22	0.81 0.69 - 0.93	0.57 0.50 - 0.65	0.20 0.15 - 0.24	0.34 0.29 - 0.38	0.59 0.53 - 0.65	1.04 0.87 - 1.20	1.64 1.36 - 1.92	2.32 1.77 - 2.87
Females										
Total, age 6–79	2830	11.06	0.56 0.52 - 0.59	0.34 0.30 - 0.37	<LOD	0.19 0.16 - 0.21	0.36 0.33 - 0.39	0.66 0.60 - 0.73	1.16 1.00 - 1.32	1.71 1.54 - 1.88
6–11	510	16.47	0.32 0.24 - 0.40	0.22 0.18 - 0.26	<LOD	0.12 <LOD - 0.16	0.25 0.21 - 0.29	0.42 0.36 - 0.48	0.56 0.44 - 0.68	0.73 0.57 - 0.88
12–19	478	12.97	0.39 0.33 - 0.46	0.28 0.23 - 0.33	<LOD	0.17 0.12 - 0.21	0.34 0.29 - 0.39	0.52 0.42 - 0.62	0.73 0.60 - 0.86	0.98 0.68 - 1.27
20–39	655	14.20	0.44 0.37 - 0.51	0.27 0.24 - 0.32	<LOD	0.16 0.13 - 0.19	0.29 0.23 - 0.36	0.53 0.44 - 0.62	0.91 0.71 - 1.12	1.32 0.90 - 1.74
40–59	645	8.06	0.67 0.62 - 0.72	0.41 0.35 - 0.46	0.10 <LOD - 0.15	0.23 0.18 - 0.27	0.41 0.34 - 0.49	0.79 0.71 - 0.87	1.48 1.33 - 1.63	2.33 1.86 - 2.80
60–79	542	4.06	0.73 0.63 - 0.84	0.45 0.38 - 0.52	0.12 0.09 - 0.15	0.23 0.18 - 0.28	0.46 0.40 - 0.52	0.90 0.73 - 1.07	1.56 1.22 - 1.90	2.21 1.80 - 2.61

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.3c

Cadmium (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5478	9.73	0.57 0.54 - 0.60	0.42 0.40 - 0.44	0.17 <LOD - 0.18	0.25 0.24 - 0.27	0.39 0.37 - 0.41	0.69 0.63 - 0.75	1.15 1.06 - 1.24	1.60 1.47 - 1.73
6–11	1030	14.76	0.42 0.33 - 0.51	0.34 0.31 - 0.38	<LOD	0.24 0.22 - 0.27	0.34 0.30 - 0.37	0.47 0.41 - 0.53	0.70 0.58 - 0.82	0.86 0.71 - 1.01
12–19	982	10.49	0.28 0.24 - 0.31	0.24 0.22 - 0.26	<LOD	0.17 0.15 - 0.19	0.24 0.22 - 0.26	0.32 0.29 - 0.34	0.42 0.35 - 0.49	0.53 0.41 - 0.66
20–39	1165	13.22	0.38 0.35 - 0.42	0.31 0.30 - 0.33	<LOD	0.21 0.19 - 0.23	0.30 0.28 - 0.32	0.46 0.43 - 0.49	0.69 0.62 - 0.77	0.83 0.68 - 0.97
40–59	1218	7.39	0.71 0.67 - 0.74	0.54 0.51 - 0.58	0.22 <LOD - 0.26	0.34 0.31 - 0.36	0.52 0.47 - 0.56	0.86 0.78 - 0.95	1.42 1.24 - 1.59	1.94 1.67 - 2.21
60–79	1083	3.14	0.88 0.80 - 0.96	0.70 0.64 - 0.77	0.31 0.28 - 0.33	0.43 0.39 - 0.47	0.69 0.62 - 0.76	1.11 0.98 - 1.25	1.64 1.52 - 1.75	2.18 1.87 - 2.49
Males										
Total, age 6–79	2652	8.30	0.46 0.42 - 0.49	0.36 0.34 - 0.38	0.16 <LOD - 0.17	0.22 0.21 - 0.24	0.34 0.32 - 0.36	0.54 0.49 - 0.60	0.93 0.79 - 1.06	1.22 1.09 - 1.34
6–11	521	13.05	0.40 0.36 - 0.45	0.34 0.32 - 0.37	<LOD	0.25 0.23 - 0.27	0.34 0.31 - 0.36	0.46 0.41 - 0.51	0.71 0.57 - 0.85	0.83 0.68 - 0.97
12–19	504	8.13	0.27 0.23 - 0.30	0.23 0.21 - 0.25	0.13 <LOD - 0.14	0.16 0.14 - 0.18	0.23 0.21 - 0.25	0.31 0.27 - 0.36	0.43 0.36 - 0.50	0.53 0.31 - 0.75
20–39	512	11.91	0.30 0.28 - 0.32	0.26 0.25 - 0.28	<LOD	0.18 0.17 - 0.19	0.26 0.23 - 0.28	0.37 0.34 - 0.41	0.53 0.46 - 0.60	0.65 0.53 - 0.77
40–59	574	6.62	0.54 0.49 - 0.59	0.43 0.40 - 0.48	0.18 <LOD - 0.21	0.29 0.24 - 0.33	0.42 0.38 - 0.47	0.70 0.59 - 0.80	1.04 0.90 - 1.17	1.24 0.99 - 1.50
60–79	541	2.22	0.75 0.63 - 0.86	0.60 0.52 - 0.69	0.27 0.24 - 0.29	0.39 0.34 - 0.43	0.56 0.48 - 0.65	1.00 0.74 - 1.27	1.47 1.25 - 1.70	1.76 1.48 - 2.04
Females										
Total, age 6–79	2826	11.08	0.68 0.63 - 0.72	0.50 0.47 - 0.53	<LOD	0.29 0.27 - 0.31	0.46 0.42 - 0.51	0.80 0.74 - 0.86	1.42 1.23 - 1.61	2.02 1.77 - 2.27
6–11	509	16.50	0.45 0.30 - 0.59	0.34 0.29 - 0.40	<LOD	0.24 <LOD - 0.27	0.33 0.29 - 0.38	0.47 0.39 - 0.56	0.70 0.56 - 0.83	0.91 0.68 - 1.13
12–19	478	12.97	0.29 0.24 - 0.33	0.25 0.22 - 0.27	<LOD	0.19 0.17 - 0.21	0.25 0.24 - 0.27	0.32 0.29 - 0.34	0.42 0.34 - 0.50	0.53 0.39 - 0.68
20–39	653	14.24	0.47 0.40 - 0.53	0.37 0.34 - 0.41	<LOD	0.25 0.22 - 0.28	0.35 0.31 - 0.38	0.55 0.49 - 0.61	0.79 0.65 - 0.93	1.11 0.81 - 1.41
40–59	644	8.07	0.87 0.82 - 0.92	0.67 0.64 - 0.71	0.28 <LOD - 0.33	0.40 0.37 - 0.44	0.66 0.60 - 0.72	1.11 1.00 - 1.23	1.87 1.59 - 2.14	2.29 2.10 - 2.47
60–79	542	4.06	1.00 0.91 - 1.10	0.81 0.75 - 0.88	0.36 0.32 - 0.40	0.52 0.47 - 0.57	0.80 0.71 - 0.89	1.23 1.03 - 1.44	1.88 1.63 - 2.14	2.43 2.08 - 2.78

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.1.4 Copper (CASRN 7440-50-8)

Copper (Cu) is the twenty-sixth most abundant element in the Earth's crust and occurs naturally in rock, soil, sediment, water, plants, and animals (CCME, 1997). Pure copper is a reddish, lustrous, malleable, and ductile metal, while many copper compounds have a blue-green colour (CCME, 1997). Copper is commonly found in the form of various sulphide minerals. It is considered an essential element required for the maintenance of health. Copper is needed for many physiological processes, including cellular respiration, iron metabolism, antioxidant defence, connective tissue development, and neurotransmitter production (WHO, 1998).

Copper is released from natural sources, including volcanoes, decaying vegetation, and forest fires, or from anthropogenic sources, such as mining, farming, manufacturing operations, and combustion of fuels and other materials containing copper. Copper is mined extensively for use in the manufacture of brass, bronze, gunmetal, and Monel metal alloys. Copper alloys are used in sheet metal, piping, and electrical conductors, with electrical wire and other electronic applications accounting for 65% of global copper use. Copper and copper alloys are also used in cooking utensils, coins, antifouling paint, dental amalgams, plumbing fixtures and pipes, and architectural applications such as roofing, guttering, and flashing. In addition, copper compounds are important chemicals in the textile, petroleum refining, wood preservative, and agricultural industries (CCME, 1997; ATSDR, 2004; WHO, 1998; Health Canada, 2007).

For the general population, most exposure to copper originates from food (CCME, 1997), although additional exposure may result from inhalation of dust particles, from ingestion of drinking water that contains copper, or by hand-to-mouth activity after skin contact with soil, water, and other copper-containing substances. Copper is an essential nutrient for humans and functions mainly as a catalytic co-factor for enzymes, and therefore a certain amount is required for growth and proper functioning of physiological processes. The estimated average requirement (EAR) for copper ranges from 260 µg/day for young children to 1000 µg/day during lactation, and the recommended dietary allowance (RDA) ranges from 340 µg/day for young children to 1300 µg/day during lactation; the adequate intake (AI) for infants (0–12 months) ranges from 200 to 220 µg/day (Health Canada, 2005; IOM, 2001). Overt copper deficiency is relatively rare, but has been associated with effects such as anaemia, neutropenia, and bone abnormalities (WHO, 1998).

Approximately 24–60% of copper is absorbed following oral ingestion; absorption is affected by a number of factors, including the amount of copper in the diet, presence of other metals such as zinc, iron, molybdenum, lead, and cadmium, and age (ATSDR, 2004; WHO, 1998). Following ingestion, absorbed copper is bound to plasma protein carriers such as ceruloplasmin and is transported to the liver. Copper is then re-distributed from the liver to other tissues, where it is stored bound to metallothionein and amino acids (ATSDR, 2004). Bile is the major excretory route for copper; up to 70% of orally ingested copper may be excreted in the feces. Normally 0.5–3.0% of daily copper intake is excreted in the urine (ATSDR, 2004). Exposure to copper can lead to increased copper concentrations in whole blood, serum, urine, hair and the liver. Copper concentrations in serum have been observed to decrease rapidly after exposure, indicating that they may only reflect recent exposures. Copper concentrations in hair and fingernails/toenails have also been used to evaluate exposure, and may reflect exposure over longer periods of time (ATSDR, 2004).

High doses of copper may result in adverse effects, although toxic effects from copper are rare in the general population. Hemodialysis patients, individuals with the genetic disorder Wilson's disease, and those with chronic liver disease may be more susceptible to copper toxicity (WHO, 1998). Acute oral exposure to high doses of copper has been associated with nausea, vomiting, and diarrhea. When inhaled, copper is a respiratory tract irritant. Metal fume fever has been associated with exposure to high concentrations of metal fumes, including copper, generally in an industrial setting. Eye irritation from exposure to copper dust has also been reported (ATSDR, 2004; WHO, 1998). The International Agency for Research on Cancer (IARC) has not reviewed copper for its carcinogenic potential; the US Environmental Protection Agency (US EPA, 1988) concluded that there were no human data and inadequate animal data to assess the carcinogenicity of copper and copper compounds.

Health Canada (2006) has adopted tolerable Upper Intake Levels (UL) for copper that are based on liver damage as the critical adverse effect. The ULs for copper are 1 mg/day for children 1 to 3 years old, 3 mg/day for children 4 to 8 years old, 5 mg/day for children 9 to 13 years old, 8 mg/day for adolescents (14–18 years old), and 10 mg/day for adults (IOM, 2001). Health Canada (1992) has established an aesthetic objective for drinking water of ≤1 mg/L based on palatability and staining of laundry and plumbing fixtures; this guideline was also deemed protective of adverse health effects.

In a study carried out in British Columbia, 61 non-smoking participants aged 30–65 were assessed for the levels of various trace elements in blood and urine. The geometric mean and 95th percentile values of copper in urine were 10.67 μg/g creatinine and 19.66 μg/g creatinine, respectively (Clark et al., 2007).

Copper was measured in the blood and urine of all participants aged 6–79 years in the Canadian Health Measures Survey and is presented as μg/L in blood and as both μg/L and μg/g creatinine in urine (Tables 8.1.4a, 8.1.4b, 8.1.4c). Finding a measurable amount of copper in blood or urine is an indicator of exposure to copper and does not necessarily mean that an adverse health effect will occur. Because copper is an essential nutrient for the maintenance of health its presence is expected. These data provide reference ranges for blood and urinary levels of copper in the Canadian population.

Table 8.1.4a

Copper – Arithmetic and geometric means, and selected percentiles of blood concentrations (μg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5318	0.00	927.91 912.55 - 943.28	912.76 898.08 - 927.68	747.93 736.30 - 759.57	812.91 797.98 - 827.84	887.56 870.76 - 904.35	994.68 975.29 - 1014.08	1138.95 1119.15 - 1158.74	1256.11 1225.82 - 1286.41
6–11	909	0.00	981.59 959.10 - 1004.07	972.64 950.95 - 994.82	824.63 789.91 - 859.36	892.74 864.92 - 920.57	971.55 959.29 - 983.82	1050.89 1025.79 - 1075.99	1139.73 1092.73 - 1186.72	1197.71 1149.07 - 1246.36
12–19	945	0.00	914.10 887.04 - 941.17	894.17 871.18 - 917.76	724.29 701.74 - 746.85	780.04 761.94 - 798.14	855.45 843.30 - 867.61	968.19 925.76 - 1010.62	1169.56 1088.16 - 1250.96	1374.50 1179.28 - 1569.72
20–39	1165	0.00	939.88 921.60 - 958.17	917.24 900.63 - 934.16	732.21 715.69 - 748.72	792.57 773.59 - 811.55	868.89 845.35 - 892.43	999.12 965.91 - 1032.33	1238.05 1195.39 - 1280.71	1417.19 1336.55 - 1497.83
40–59	1220	0.00	912.09 894.92 - 929.27	902.34 885.60 - 919.39	757.61 738.65 - 776.56	817.21 793.62 - 840.81	882.49 866.34 - 898.63	981.04 958.60 - 1003.48	1080.33 1052.20 - 1108.46	1166.46 1131.25 - 1201.67
60–79	1079	0.00	926.19 906.71 - 945.67	915.59 897.32 - 934.23	769.50 748.33 - 790.68	829.39 811.53 - 847.25	901.40 881.65 - 921.15	996.42 971.09 - 1021.75	1101.17 1055.32 - 1147.02	1182.98 1118.82 - 1247.14
Males										
Total, age 6–79	2575	0.00	856.94 840.12 - 873.76	849.49 833.41 - 865.87	722.24 707.97 - 736.52	779.36 767.52 - 791.20	844.39 830.58 - 858.19	909.55 889.73 - 929.37	1007.64 975.77 - 1039.51	1059.89 1023.34 - 1096.44
6–11	458	0.00	1002.59 979.22 - 1025.97	994.49 972.69 - 1016.79	843.62 820.25 - 866.98	921.11 907.96 - 934.26	987.64 972.54 - 1002.74	1059.46 1028.63 - 1090.29	1154.93 1093.78 - 1216.08	1220.83 1143.37 - 1298.29
12–19	489	0.00	841.19 822.65 - 859.73	833.49 815.88 - 851.47	700.69 677.03 - 724.34	761.33 740.76 - 781.89	824.91 803.99 - 845.84	892.17 866.51 - 917.82	1003.67 951.26 - 1056.07	1083.43 1020.94 - 1145.91
20–39	514	0.00	827.54 806.19 - 848.89	821.64 801.92 - 841.84	704.68 682.87 - 726.50	755.78 741.65 - 769.92	816.43 795.78 - 837.09	879.94 855.47 - 904.41	946.30 893.05 - 999.56	1016.39 942.92 - 1089.87
40–59	577	0.00	855.07 837.59 - 872.56	848.90 831.63 - 866.53	732.66 705.98 - 759.33	781.18 766.77 - 795.58	849.63 835.66 - 863.61	898.92 877.06 - 920.78	986.31 941.64 - 1030.97	1029.77 1003.02 - 1056.53
60–79	537	0.00	869.67 849.62 - 889.71	862.59 843.65 - 881.95	737.75 722.61 - 752.89	796.64 778.11 - 815.18	863.66 841.63 - 885.69	918.74 895.70 - 941.79	997.32 952.40 - 1042.24	1056.03 998.36 - 1113.70
Females										
Total, age 6–79	2743	0.00	999.38 983.35 - 1015.41	981.24 966.43 - 996.27	795.67 774.63 - 816.70	860.53 846.58 - 874.49	954.60 941.08 - 968.11	1071.92 1051.51 - 1092.33	1245.00 1219.78 - 1270.21	1396.58 1321.55 - 1471.62
6–11	451	0.00	959.34 934.22 - 984.46	950.01 924.85 - 975.86	789.13 745.66 - 832.60	867.92 832.86 - 902.97	955.36 934.75 - 975.98	1024.10 990.48 - 1057.73	1123.17 1076.96 - 1169.38	1189.36 1145.93 - 1232.78
12–19	456	0.00	994.17 948.01 - 1040.32	965.89 926.76 - 1006.67	757.13 740.77 - 773.49	813.55 774.49 - 852.60	918.91 886.81 - 951.00	1102.16 999.60 - 1204.72	1376.63 1177.55 - 1575.72	1552.75 1395.75 - 1709.75
20–39	651	0.00	1056.06 1032.68 - 1079.44	1027.82 1006.59 - 1049.51	796.60 754.42 - 838.77	860.77 835.34 - 886.21	981.17 959.00 - 1003.35	1196.40 1145.98 - 1246.82	1419.10 1337.39 - 1500.81	1575.72 1457.55 - 1693.88
40–59	643	0.00	968.72 949.06 - 988.38	958.75 939.80 - 978.07	801.61 766.86 - 836.37	868.91 849.43 - 888.40	951.29 931.45 - 971.13	1042.72 1011.11 - 1074.33	1152.34 1110.20 - 1194.47	1222.73 1166.99 - 1278.47
60–79	542	0.00	977.94 956.44 - 999.44	966.97 947.32 - 987.02	819.51 802.07 - 836.96	871.75 851.57 - 891.93	952.53 934.36 - 970.69	1041.69 1018.34 - 1065.03	1144.88 1077.90 - 1211.87	1251.24 1190.79 - 1311.70

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.4b

Copper – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5492	0.29	11.89 11.28 - 12.50	8.98 8.24 - 9.79	3.04 2.48 - 3.60	5.64 4.87 - 6.42	9.99 9.29 - 10.69	15.51 14.61 - 16.40	21.51 19.92 - 23.10	26.67 25.10 - 28.24
6–11	1034	0.29	13.86 12.35 - 15.37	10.48 9.37 - 11.72	3.77 2.93 - 4.62	7.06 5.83 - 8.30	11.92 10.67 - 13.17	17.44 16.18 - 18.70	23.07 19.86 - 26.28	27.48 25.39 - 29.57
12–19	983	0.31	15.90 15.04 - 16.75	12.17 10.93 - 13.55	4.38 3.13 - 5.64	8.65 6.95 - 10.36	13.78 12.77 - 14.79	19.50 18.19 - 20.81	27.67 25.17 - 30.17	32.47 30.00 - 34.95
20–39	1169	0.43	11.45 10.55 - 12.36	8.60 7.57 - 9.78	3.01 2.25 - 3.76	5.54 4.53 - 6.56	9.45 8.33 - 10.56	15.20 14.16 - 16.23	20.78 19.23 - 22.32	25.64 23.03 - 28.25
40–59	1223	0.41	10.82 10.01 - 11.63	8.16 7.42 - 8.97	2.68 2.17 - 3.19	4.85 3.93 - 5.76	9.17 8.40 - 9.93	14.49 13.43 - 15.55	20.26 18.82 - 21.71	24.44 22.33 - 26.54
60–79	1083	0.00	11.34 10.59 - 12.08	9.00 8.39 - 9.66	3.48 2.87 - 4.08	5.68 5.00 - 6.37	9.80 9.11 - 10.50	14.29 13.50 - 15.09	20.27 18.08 - 22.45	24.37 21.35 - 27.38
Males										
Total, age 6–79	2662	0.23	12.75 11.98 - 13.53	10.07 9.31 - 10.91	3.84 3.15 - 4.52	6.90 6.15 - 7.64	11.37 10.73 - 12.01	16.46 15.37 - 17.54	22.58 20.75 - 24.40	27.12 25.65 - 28.59
6–11	524	0.00	13.67 11.23 - 16.11	10.71 8.85 - 12.97	3.89 2.49 - 5.30	7.20 5.45 - 8.94	12.18 10.12 - 14.23	17.47 15.64 - 19.30	23.86 19.76 - 27.95	27.14 25.35 - 28.93
12–19	505	0.40	14.45 13.14 - 15.76	11.80 10.25 - 13.60	4.77 3.34 - 6.19	9.09 7.44 - 10.74	13.53 12.46 - 14.60	17.85 16.11 - 19.59	25.21 22.69 - 27.72	28.74 25.98 - 31.49
20–39	514	0.19	12.09 10.91 - 13.27	9.46 8.20 - 10.92	3.33 1.69 - 4.98	6.48 5.17 - 7.80	10.36 8.95 - 11.77	16.52 15.03 - 18.01	21.76 19.32 - 24.21	26.33 23.42 - 29.24
40–59	578	0.52	12.42 11.11 - 13.74	9.63 8.63 - 10.74	3.62 2.95 - 4.28	6.29 5.45 - 7.13	11.41 10.26 - 12.56	15.93 14.11 - 17.74	22.35 18.82 - 25.88	27.22 23.12 - 31.32
60–79	541	0.00	13.05 11.97 - 14.14	10.82 9.94 - 11.77	4.78 4.18 - 5.38	7.74 7.01 - 8.46	11.25 10.17 - 12.33	15.96 14.08 - 17.85	22.08 19.41 - 24.76	27.54 23.50 - 31.59
Females										
Total, age 6–79	2830	0.35	11.03 10.34 - 11.72	8.01 7.26 - 8.84	2.78 2.39 - 3.17	4.79 4.11 - 5.47	8.84 7.97 - 9.72	14.31 13.51 - 15.11	20.62 19.32 - 21.92	25.43 23.18 - 27.67
6–11	510	0.59	14.07 12.66 - 15.47	10.23 9.39 - 11.14	3.59 2.77 - 4.40	6.81 5.60 - 8.02	11.69 10.65 - 12.73	17.43 16.12 - 18.73	22.64 20.38 - 24.90	28.06 23.75 - 32.38
12–19	478	0.21	17.48 15.05 - 19.90	12.58 10.87 - 14.56	3.81 2.16 - 5.46	7.95 5.41 - 10.49	15.03 13.19 - 16.87	22.44 19.72 - 25.15	30.86 28.56 - 33.16	34.46 30.26 - 38.67
20–39	655	0.61	10.81 9.79 - 11.84	7.82 6.86 - 8.91	2.92 2.45 - 3.39	5.08 4.36 - 5.79	8.60 7.16 - 10.04	13.73 12.62 - 14.85	19.46 17.98 - 20.93	23.89 20.17 - 27.60
40–59	645	0.31	9.23 8.33 - 10.14	6.93 6.12 - 7.85	2.30 1.77 - 2.84	3.92 2.91 - 4.93	7.60 6.33 - 8.87	12.61 11.27 - 13.95	19.07 17.22 - 20.91	21.87 18.50 - 25.24
60–79	542	0.00	9.76 8.85 - 10.67	7.61 6.80 - 8.51	2.87 2.35 - 3.39	4.54 3.88 - 5.20	8.08 6.70 - 9.46	12.53 11.54 - 13.53	16.92 15.34 - 18.50	23.03 20.36 - 25.70

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.4c

Copper (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5479	0.29	12.44 11.60 - 13.27	10.86 10.46 - 11.28	7.38 7.08 - 7.68	8.69 8.43 - 8.95	10.62 10.36 - 10.88	13.04 12.65 - 13.43	16.85 16.34 - 17.36	20.42 19.50 - 21.33
6–11	1031	0.29	20.03 11.16 - 28.89	16.09 15.23 - 17.01	11.61 11.00 - 12.21	13.41 12.80 - 14.02	15.75 15.05 - 16.45	18.85 17.87 - 19.83	22.32 20.17 - 24.47	26.92 23.68 - 30.16
12–19	982	0.31	12.17 10.78 - 13.55	10.60 10.20 - 11.01	7.41 7.01 - 7.81	8.54 8.25 - 8.82	10.11 9.62 - 10.61	12.42 11.83 - 13.00	15.84 14.95 - 16.73	20.03 17.46 - 22.59
20–39	1165	0.43	11.02 10.14 - 11.89	9.60 9.12 - 10.11	6.70 6.35 - 7.05	7.93 7.64 - 8.23	9.52 9.12 - 9.93	11.31 10.84 - 11.77	13.78 13.03 - 14.54	15.68 14.25 - 17.11
40–59	1218	0.41	11.56 10.46 - 12.66	10.46 9.92 - 11.04	7.45 7.09 - 7.80	8.75 8.33 - 9.16	10.42 9.93 - 10.91	12.32 11.87 - 12.78	14.78 13.88 - 15.67	17.43 16.58 - 18.29
60–79	1083	0.00	13.69 13.15 - 14.22	12.59 12.22 - 12.97	8.67 8.10 - 9.25	10.15 9.83 - 10.46	12.13 11.61 - 12.64	14.76 14.05 - 15.48	19.36 18.09 - 20.64	22.46 19.15 - 25.77
Males										
Total, age 6–79	2653	0.23	11.41 10.04 - 12.78	9.95 9.50 - 10.42	6.92 6.64 - 7.19	7.95 7.69 - 8.21	9.58 9.26 - 9.91	11.83 11.44 - 12.23	15.34 14.47 - 16.22	18.49 17.67 - 19.31
6–11	522	0.00	21.84 4.55 - 39.13	16.23 15.34 - 17.16	11.69 11.24 - 12.15	13.13 12.20 - 14.05	15.61 15.05 - 16.17	18.58 17.49 - 19.67	22.67 18.96 - 26.38	27.34 22.86 - 31.82
12–19	504	0.40	10.70 10.06 - 11.33	9.95 9.31 - 10.65	7.20 6.79 - 7.62	8.21 7.84 - 8.58	9.61 9.11 - 10.11	12.18 11.28 - 13.07	15.24 13.58 - 16.90	17.91 15.81 - 20.01
20–39	512	0.20	9.41 8.46 - 10.36	8.67 8.15 - 9.22	6.41 6.11 - 6.71	7.29 6.82 - 7.77	8.51 7.98 - 9.05	10.19 9.61 - 10.76	11.77 10.66 - 12.87	13.23 11.99 - 14.47
40–59	574	0.52	10.64 8.77 - 12.50	9.49 8.83 - 10.20	7.09 6.76 - 7.42	7.98 7.62 - 8.33	9.47 9.01 - 9.92	11.19 10.80 - 11.59	13.18 12.10 - 14.26	16.47 13.72 - 19.21
60–79	541	0.00	12.56 11.51 - 13.61	11.41 10.78 - 12.07	7.74 7.19 - 8.29	9.21 8.70 - 9.71	10.94 10.26 - 11.61	13.37 12.59 - 14.15	17.00 15.10 - 18.89	20.48 17.03 - 23.94
Females										
Total, age 6–79	2826	0.35	13.46 12.71 - 14.21	11.86 11.42 - 12.31	8.19 7.72 - 8.65	9.68 9.36 - 9.99	11.49 11.18 - 11.81	14.01 13.53 - 14.49	17.95 17.05 - 18.86	21.80 20.32 - 23.28
6–11	509	0.59	18.12 16.18 - 20.05	15.95 14.73 - 17.28	11.35 10.11 - 12.59	13.52 12.94 - 14.10	16.08 15.14 - 17.01	19.11 18.19 - 20.04	22.32 20.79 - 23.85	25.20 21.98 - 28.41
12–19	478	0.21	13.77 10.60 - 16.94	11.35 10.82 - 11.90	7.73 7.17 - 8.28	9.00 8.31 - 9.70	10.57 9.95 - 11.20	12.63 12.02 - 13.24	16.76 13.63 - 19.88	25.20 17.43 - 32.98
20–39	653	0.61	12.64 10.74 - 14.54	10.64 9.99 - 11.34	7.75 7.31 - 8.20	9.00 8.59 - 9.40	10.72 10.19 - 11.25	12.33 11.82 - 12.85	15.30 14.31 - 16.28	18.60 14.57 - 22.63
40–59	644	0.31	12.47 11.70 - 13.24	11.53 10.98 - 12.10	8.22 7.46 - 8.97	9.75 9.30 - 10.20	11.37 10.79 - 11.94	13.24 12.69 - 13.79	16.01 14.12 - 17.90	19.94 16.21 - 23.67
60–79	542	0.00	14.72 14.16 - 15.28	13.78 13.25 - 14.34	9.96 9.21 - 10.71	11.35 10.99 - 11.71	13.08 12.43 - 13.72	16.06 14.92 - 17.21	20.38 18.98 - 21.78	24.45 20.87 - 28.03

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.1.5 Lead (CASRN 7439-92-1)

Lead (Pb) is a naturally occurring element found in rock and soil. It is a heavy metal and can exist in various oxidation states and in both inorganic and organic forms. Inorganic lead includes substances such as elemental lead, lead sulphate, lead carbonates and oxycarbonates, lead oxides, and lead halides. Organic lead compounds include tetra-, tri-, and dialkyl lead compounds.

Lead is currently used in the refining and manufacturing of products such as lead acid car batteries, lead shot and fishing weights, sheet lead, solder, some brass and bronze products, pipes, artists' paints (other than paints for use by children), and some ceramic glazes. Other uses of lead include dyes in paints and pigments, medical equipment (e.g., radiation shields), scientific equipment, and military equipment (ATSDR, 2007; WHO, 2000).

Lead enters the environment from a variety of natural and human sources. Natural processes, such as soil weathering, erosion, and volcanic activity, release lead, but these processes rarely result in elevated concentrations in the environment, with the exception of areas with naturally enriched soils. However, human industrial activities release more lead and frequently result in sites of local contamination. Lead released from industrial emissions into the atmosphere can be a major source of environmental contamination, especially near "point sources" such as smelters or refineries. Historical use of leaded motor fuels also resulted in the ubiquitous distribution of lead throughout the environment (WHO, 2000).

Everyone is exposed to trace amounts of lead through soil, household dust, food, drinking water, and air due to lead's natural abundance in the environment and its widespread use for much of the twentieth century. Lead exposure in Canada has decreased substantially since the early 1970s, mainly because leaded gasoline and lead-based paints were phased out and the use of lead solder in food cans was virtually eliminated (Health Canada, 2008). Current potential sources of lead exposure include ingestion of chips and dust from lead-based paints on interior and exterior surfaces of older buildings; ingestion of water from drinking water distribution systems containing lead pipes, lead plumbing fittings, or lead-based solder; ingestion of food grown in areas with high levels of lead in air, water, or soil, (e.g., near base metal smelters, combustion sources, roads, or in cities); and mouthing of toys or other consumer products containing lead or coated with lead-based paints or glazes (Health Canada, 2007).

While only about 10% of the lead ingested by adults is absorbed from the intestine into the blood, about 40% of ingested lead is absorbed by the bodies of preschool children (Health Canada, 2002). Once absorbed by the human body, lead circulates in the bloodstream and either accumulates in tissues (especially in bone) or is excreted from the body as waste. Some lead may also be absorbed into soft tissues such as the liver, kidneys, pancreas, and lungs. Whereas approximately 70% of the total body burden of lead is located in the bones of children, more than 90% of the total body burden of lead is found in the bones in human adults (US EPA, 2006). Blood and soft tissues represent the active pool for lead, while bone acts as a storage pool; thus, bone lead is considered a biomarker of long-term exposure (ATSDR, 2007). Bone lead can be re-mobilized into the circulating pool of lead, particularly during physiological states of stress associated with increased bone resorption, such as pregnancy, lactation, menopause, extended bed rest, hyperparathyroidism, and osteoporosis (Health Canada, 2002; Rothenberg et al., 2000). In pregnant women, lead stored in bone can act as a source of fetal lead exposure (Rothenberg et al., 2000). Lead is also present in breast milk and can be transferred from lactating mothers to infants (ATSDR, 2007; US EPA, 2006). Blood lead concentrations decrease slowly after exposure, with a half-life of about two to six weeks (Health Canada, 1992). The half-life for lead accumulated in the body, such as in bone, is around 25 to 30 years (Health Canada, 2007; ATSDR, 2007). Blood lead is the preferred method of evaluating human exposure to lead, although other matrices such as urine, bone, hair, and teeth have also been used (CDC, 2005; ATSDR, 2007).

Due to the ability of lead to persist in the body, it is considered a cumulative general poison, with infants, toddlers, children, fetuses, and pregnant women being most susceptible to adverse health effects (US EPA, 2006; Health Canada, 2007). Following acute high-level exposure, lead interferes with a variety of metabolic processes and can cause vomiting, diarrhea, convulsion, coma, and death, although severe cases of lead poisoning are rarely reported in Canada (Health Canada, 2007). Symptoms of long-term exposure to lower lead levels are less evident. Chronic low-level exposure may affect both the central and peripheral nervous systems (ATSDR, 2007). Lead has also been associated with effects on the cardiovascular system (e.g., blood pressure), kidneys, blood, and the immune system (ATSDR, 2007). Cognitive and neurobehavioral effects have been recognized as major concerns for children exposed to lead. Recently, a pooled analysis of several epidemiological studies suggested that deficits in IQ may be associated with elevated blood lead levels (ATSDR 2007). There is no known threshold for the effects of lead exposure on cognitive function and neurobehavioural development (US EPA, 2006; CDC, 2002). The International Agency for Research on Cancer (IARC) classifies inorganic lead compounds as probable human carcinogens (Group 2A) (IARC, 2004).

Lead is listed on Schedule 1 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999), the primary federal legislation that deals with industrial chemicals, and this allows the federal government to control the importation, manufacture, distribution, and use of lead and lead compounds in Canada (Health Canada, 2007). CEPA 1999 restricts the use of lead in gasoline and controls its release from secondary lead smelters and steel mills. The use of lead in various toys and other consumer products, which represent a potential risk of lead exposure, is restricted under the *Hazardous Products Act* and its associated regulations (e.g., Hazardous Products [Glazed Ceramics and Glassware] Regulations, Hazardous Products [Toys] Regulations, Surface Coating Materials Regulations) (Health Canada, 2007). The Guideline for Canadian Drinking Water Quality for lead was established as a maximum acceptable concentration of 0.010 mg/L (10 µg/L) (based on a two-year old child as the sensitive sub-group) (Health Canada, 1992).

In 1994, the Federal-Provincial-Territorial Committee on Environmental and Occupational Health recommended a blood lead intervention level of 10 µg/dL. Recent scientific studies indicate that chronic health effects may be occurring in children at blood lead levels below 10 µg/dL (Health Canada, 2007). In recognition of this, Health Canada has undertaken a comprehensive toxicological assessment of the current science on lead and, concurrently, is developing a risk management approach. The new evidence provided in the toxicological assessment will also provide a basis for Health Canada's review of its blood lead intervention levels.

In a study carried out in the region of Québec City on 441 adults aged 18–65, the geometric mean and 90th percentile blood lead concentrations were 2.15 and 4.21 µg/dL, respectively. The geometric and 90th percentile urine lead concentrations were 0.12 and 0.29 µg/dL, respectively (INSPQ, 2004). Higher lead levels have been found in some northern communities; a geometric mean blood level of 3.9 µg/dL was measured from 917 adults aged 18–74 in Nunavik, Québec in 2004 (Dewailly et al., 2007).

Levels of lead in blood and urine were measured in all participants aged 6–79 years in the Canadian Health Measures Survey and presented as µg/dL in blood and as both µg/L and µg/g creatinine in urine (Tables 8.1.5a, 8.1.5b, 8.1.5c). Finding a measurable amount of lead in blood and urine does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for blood and urinary levels of lead in the Canadian population.

Table 8.1.5a

Lead – Arithmetic and geometric means, and selected percentiles of blood concentrations (μg/dL) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5319	0.02	1.66 1.52 - 1.79	1.34 1.24 - 1.44	0.60 0.56 - 0.65	0.86 0.79 - 0.93	1.30 1.21 - 1.39	2.03 1.83 - 2.22	3.07 2.77 - 3.37	3.79 3.32 - 4.26
6–11	910	0.00	1.02 0.91 - 1.13	0.90 0.81 - 0.99	0.53 0.49 - 0.57	0.65 0.59 - 0.70	0.87 0.77 - 0.97	1.19 1.05 - 1.34	1.61 1.47 - 1.76	1.95 1.65 - 2.26
12–19	945	0.00	0.89 0.81 - 0.97	0.80 0.74 - 0.85	0.47 0.44 - 0.51	0.57 0.53 - 0.62	0.76 0.70 - 0.83	1.05 0.99 - 1.11	1.34 1.11 - 1.56	1.64 1.47 - 1.82
20–39	1165	0.09	1.37 1.27 - 1.46	1.12 1.04 - 1.21	0.57 0.52 - 0.62	0.76 0.69 - 0.82	1.05 0.99 - 1.11	1.58 1.39 - 1.77	2.35 2.02 - 2.68	3.12 2.75 - 3.49
40–59	1220	0.00	1.87 1.67 - 2.07	1.60 1.46 - 1.75	0.82 0.70 - 0.95	1.15 1.06 - 1.24	1.55 1.43 - 1.67	2.22 1.95 - 2.50	3.17 2.71 - 3.63	3.87 3.16 - 4.57
60–79	1079	0.00	2.49 2.22 - 2.77	2.08 1.90 - 2.29	1.04 0.93 - 1.14	1.44 1.33 - 1.56	2.07 1.90 - 2.24	3.02 2.68 - 3.37	4.17 3.53 - 4.81	5.19 4.20 - 6.18
Males										
Total, age 6–79	2576	0.00	1.86 1.69 - 2.03	1.51 1.40 - 1.63	0.71 0.66 - 0.76	1.01 0.95 - 1.06	1.44 1.34 - 1.54	2.21 2.01 - 2.42	3.26 2.87 - 3.66	4.22 3.71 - 4.72
6–11	459	0.00	1.04 0.94 - 1.14	0.92 0.85 - 0.99	0.54 0.50 - 0.58	0.66 0.61 - 0.72	0.89 0.79 - 1.00	1.21 1.10 - 1.31	1.64 1.44 - 1.83	1.96 1.78 - 2.13
12–19	489	0.00	0.99 0.88 - 1.11	0.88 0.82 - 0.96	0.51 0.46 - 0.55	0.65 0.60 - 0.69	0.87 0.79 - 0.95	1.16 1.05 - 1.27	1.53 1.29 - 1.77	1.79 1.28 - 2.29
20–39	514	0.00	1.70 1.56 - 1.85	1.41 1.28 - 1.55	0.75 0.65 - 0.85	0.97 0.87 - 1.07	1.30 1.15 - 1.46	2.00 1.68 - 2.33	2.94 2.59 - 3.30	3.65 2.88 - 4.42
40–59	577	0.00	2.01 1.75 - 2.27	1.74 1.57 - 1.92	0.98 0.89 - 1.08	1.25 1.15 - 1.35	1.61 1.46 - 1.77	2.35 1.92 - 2.77	3.31 2.77 - 3.85	3.95 3.02 - 4.88
60–79	537	0.00	2.78 2.46 - 3.10	2.31 2.08 - 2.57	1.20 1.07 - 1.34	1.55 1.37 - 1.73	2.24 1.98 - 2.49	3.27 2.86 - 3.68	4.86 3.96 - 5.75	6.17 4.95 - 7.39
Females										
Total, age 6–79	2743	0.04	1.45 1.30 - 1.60	1.18 1.08 - 1.30	0.55 0.50 - 0.60	0.74 0.68 - 0.81	1.14 1.04 - 1.25	1.74 1.51 - 1.97	2.73 2.35 - 3.12	3.50 3.03 - 3.97
6–11	451	0.00	0.99 0.85 - 1.13	0.87 0.77 - 0.99	0.51 0.46 - 0.57	0.64 0.57 - 0.70	0.85 0.73 - 0.97	1.16 0.93 - 1.39	1.61 1.37 - 1.86	1.93 1.26 - 2.60
12–19	456	0.00	0.77 0.72 - 0.83	0.71 0.66 - 0.77	0.43 0.37 - 0.49	0.53 0.48 - 0.58	0.68 0.62 - 0.75	0.91 0.79 - 1.04	1.16 0.98 - 1.33	1.46 1.25 - 1.67
20–39	651	0.15	1.02 0.92 - 1.12	0.89 0.81 - 0.98	0.52 0.46 - 0.57	0.64 0.60 - 0.68	0.86 0.77 - 0.96	1.19 1.08 - 1.30	1.64 1.38 - 1.91	2.05 1.78 - 2.32
40–59	643	0.00	1.72 1.51 - 1.94	1.47 1.31 - 1.65	0.71 0.59 - 0.82	1.05 0.90 - 1.19	1.46 1.27 - 1.64	2.11 1.81 - 2.41	3.11 2.49 - 3.74	3.78 3.05 - 4.52
60–79	542	0.00	2.23 1.92 - 2.54	1.89 1.69 - 2.12	0.94 0.81 - 1.07	1.34 1.15 - 1.52	1.93 1.69 - 2.18	2.67 2.27 - 3.06	3.69 3.20 - 4.17	4.53 3.81 - 5.25

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.5b

Lead – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5492	7.54	0.76 0.68 - 0.84	0.48 0.43 - 0.54	0.13 0.11 - 0.16	0.28 0.24 - 0.32	0.53 0.47 - 0.58	0.92 0.83 - 1.01	1.56 1.37 - 1.76	2.11 1.83 - 2.40
6–11	1034	9.28	0.55 0.50 - 0.60	0.36 0.33 - 0.40	<LOD <LOD - 0.16	0.22 0.18 - 0.26	0.41 0.37 - 0.45	0.65 0.57 - 0.73	1.01 0.89 - 1.13	1.31 1.12 - 1.49
12–19	983	10.17	0.60 0.52 - 0.68	0.39 0.35 - 0.44	<LOD	0.24 0.21 - 0.28	0.43 0.41 - 0.46	0.74 0.64 - 0.83	1.16 1.02 - 1.29	1.55 1.27 - 1.82
20–39	1169	9.50	0.64 0.58 - 0.71	0.41 0.35 - 0.47	0.11 <LOD - 0.14	0.24 0.19 - 0.29	0.45 0.39 - 0.51	0.75 0.63 - 0.87	1.32 1.10 - 1.55	1.83 1.59 - 2.07
40–59	1223	5.97	0.84 0.70 - 0.98	0.55 0.47 - 0.63	0.17 0.13 - 0.21	0.32 0.26 - 0.38	0.61 0.56 - 0.67	1.02 0.89 - 1.14	1.67 1.31 - 2.02	2.26 1.69 - 2.84
60–79	1083	3.14	1.01 0.90 - 1.12	0.66 0.60 - 0.73	0.20 0.15 - 0.25	0.37 0.32 - 0.42	0.68 0.62 - 0.74	1.28 1.13 - 1.43	2.12 1.82 - 2.43	2.74 2.10 - 3.37
Males										
Total, age 6–79	2662	5.86	0.85 0.75 - 0.94	0.55 0.49 - 0.61	0.15 0.11 - 0.19	0.33 0.30 - 0.36	0.60 0.55 - 0.65	1.02 0.92 - 1.12	1.71 1.47 - 1.94	2.27 1.83 - 2.70
6–11	524	6.87	0.53 0.45 - 0.61	0.38 0.32 - 0.46	0.12 <LOD - 0.17	0.23 0.17 - 0.29	0.43 0.33 - 0.53	0.69 0.58 - 0.80	1.02 0.83 - 1.21	1.34 1.06 - 1.63
12–19	505	9.11	0.56 0.46 - 0.65	0.38 0.33 - 0.44	<LOD	0.25 0.21 - 0.29	0.42 0.38 - 0.46	0.69 0.60 - 0.79	1.02 0.83 - 1.20	1.37 0.93 - 1.81
20–39	514	7.00	0.74 0.63 - 0.84	0.47 0.38 - 0.58	0.11 <LOD - 0.15	0.30 0.22 - 0.38	0.53 0.42 - 0.64	0.95 0.77 - 1.14	1.61 1.31 - 1.91	1.99 1.50 - 2.47
40–59	578	4.67	0.95 0.76 - 1.15	0.63 0.55 - 0.72	0.18 0.13 - 0.23	0.38 0.28 - 0.47	0.67 0.61 - 0.73	1.12 0.96 - 1.27	1.73 1.19 - 2.28	2.64 1.79 - 3.50
60–79	541	2.03	1.18 1.03 - 1.34	0.84 0.74 - 0.95	0.31 0.23 - 0.38	0.51 0.44 - 0.57	0.84 0.67 - 1.00	1.53 1.28 - 1.78	2.25 1.98 - 2.51	3.07 2.61 - 3.54
Females										
Total, age 6–79	2830	9.12	0.67 0.59 - 0.76	0.43 0.37 - 0.48	0.13 <LOD - 0.15	0.23 0.19 - 0.27	0.45 0.39 - 0.51	0.80 0.69 - 0.91	1.36 1.16 - 1.55	1.86 1.55 - 2.17
6–11	510	11.76	0.57 0.51 - 0.63	0.34 0.31 - 0.38	<LOD	0.20 0.16 - 0.25	0.40 0.38 - 0.43	0.62 0.56 - 0.69	0.99 0.84 - 1.14	1.29 1.06 - 1.51
12–19	478	11.30	0.65 0.51 - 0.79	0.40 0.35 - 0.46	<LOD <LOD - 0.17	0.23 0.18 - 0.28	0.44 0.40 - 0.48	0.79 0.68 - 0.91	1.30 1.02 - 1.58	1.62 0.93 - 2.31
20–39	655	11.45	0.55 0.46 - 0.63	0.35 0.31 - 0.41	<LOD <LOD - 0.14	0.21 0.16 - 0.26	0.39 0.34 - 0.45	0.65 0.55 - 0.76	0.95 0.78 - 1.12	1.34 1.14 - 1.55
40–59	645	7.13	0.73 0.61 - 0.84	0.48 0.40 - 0.57	0.15 0.10 - 0.20	0.25 0.18 - 0.32	0.54 0.42 - 0.65	0.95 0.85 - 1.04	1.53 1.14 - 1.93	2.09 1.62 - 2.56
60–79	542	4.24	0.85 0.70 - 1.01	0.54 0.45 - 0.64	0.14 <LOD - 0.20	0.28 0.20 - 0.36	0.57 0.45 - 0.69	1.11 0.88 - 1.34	1.76 1.46 - 2.06	2.28 1.25 - 3.32

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.5c

Lead (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5479	7.56	0.81 0.74 - 0.88	0.58 0.53 - 0.64	0.24 0.21 - 0.28	0.36 0.33 - 0.39	0.58 0.52 - 0.63	0.94 0.84 - 1.04	1.49 1.35 - 1.64	1.98 1.75 - 2.22
6–11	1031	9.31	0.76 0.66 - 0.86	0.56 0.51 - 0.61	<LOD <LOD - 0.30	0.38 0.34 - 0.42	0.54 0.47 - 0.62	0.81 0.72 - 0.91	1.22 1.08 - 1.36	1.60 1.26 - 1.95
12–19	982	10.18	0.47 0.39 - 0.55	0.34 0.30 - 0.38	<LOD	0.23 0.20 - 0.26	0.34 0.31 - 0.37	0.51 0.45 - 0.57	0.79 0.66 - 0.93	1.06 0.74 - 1.39
20–39	1165	9.53	0.65 0.58 - 0.72	0.45 0.41 - 0.50	0.21 <LOD - 0.25	0.30 0.27 - 0.32	0.45 0.42 - 0.49	0.70 0.63 - 0.77	1.01 0.87 - 1.15	1.39 1.07 - 1.70
40–59	1218	5.99	0.88 0.78 - 0.98	0.70 0.63 - 0.78	0.31 0.27 - 0.34	0.45 0.42 - 0.49	0.70 0.62 - 0.78	1.11 0.96 - 1.26	1.61 1.35 - 1.88	2.04 1.66 - 2.42
60–79	1083	3.14	1.23 1.08 - 1.37	0.93 0.84 - 1.03	0.41 0.35 - 0.48	0.61 0.55 - 0.67	0.93 0.81 - 1.06	1.43 1.31 - 1.56	2.12 1.80 - 2.44	2.87 2.38 - 3.35
Males										
Total, age 6–79	2653	5.88	0.73 0.66 - 0.80	0.54 0.50 - 0.58	0.23 0.20 - 0.26	0.34 0.32 - 0.37	0.53 0.49 - 0.57	0.87 0.77 - 0.96	1.34 1.18 - 1.49	1.82 1.42 - 2.21
6–11	522	6.90	0.76 0.61 - 0.90	0.57 0.53 - 0.63	0.27 <LOD - 0.31	0.39 0.35 - 0.44	0.57 0.48 - 0.66	0.85 0.75 - 0.94	1.24 1.05 - 1.42	1.74 1.31 - 2.16
12–19	504	9.13	0.43 0.36 - 0.50	0.32 0.29 - 0.36	<LOD	0.21 0.20 - 0.23	0.32 0.28 - 0.35	0.51 0.44 - 0.58	0.74 0.59 - 0.90	0.96 0.59 - 1.33
20–39	512	7.03	0.58 0.52 - 0.63	0.43 0.38 - 0.49	0.21 <LOD - 0.26	0.29 0.26 - 0.32	0.44 0.40 - 0.47	0.67 0.58 - 0.76	1.02 0.81 - 1.23	1.34 0.75 - 1.94
40–59	574	4.70	0.78 0.66 - 0.90	0.62 0.55 - 0.69	0.29 0.27 - 0.31	0.40 0.36 - 0.45	0.60 0.53 - 0.68	0.94 0.78 - 1.09	1.34 1.04 - 1.64	1.80 1.10 - 2.49
60–79	541	2.03	1.14 1.00 - 1.29	0.88 0.82 - 0.96	0.42 0.39 - 0.44	0.59 0.53 - 0.64	0.87 0.77 - 0.97	1.33 1.13 - 1.53	1.84 1.49 - 2.20	2.36 1.56 - 3.17
Females										
Total, age 6–79	2826	9.13	0.89 0.79 - 0.99	0.63 0.56 - 0.71	0.25 <LOD - 0.29	0.39 0.34 - 0.43	0.63 0.55 - 0.71	1.05 0.89 - 1.21	1.64 1.38 - 1.90	2.10 1.75 - 2.44
6–11	509	11.79	0.77 0.64 - 0.90	0.54 0.48 - 0.61	<LOD	0.38 0.34 - 0.42	0.53 0.46 - 0.60	0.79 0.68 - 0.90	1.17 1.00 - 1.35	1.52 1.11 - 1.94
12–19	478	11.30	0.51 0.39 - 0.63	0.36 0.31 - 0.42	<LOD <LOD - 0.22	0.26 0.21 - 0.30	0.35 0.31 - 0.39	0.53 0.42 - 0.64	0.84 0.65 - 1.02	1.08 0.52 - 1.64
20–39	653	11.49	0.72 0.56 - 0.88	0.48 0.43 - 0.54	<LOD <LOD - 0.24	0.31 0.26 - 0.35	0.46 0.43 - 0.49	0.73 0.63 - 0.82	0.99 0.81 - 1.17	1.44 1.02 - 1.87
40–59	644	7.14	0.98 0.85 - 1.11	0.79 0.69 - 0.91	0.35 0.26 - 0.44	0.51 0.43 - 0.58	0.79 0.69 - 0.89	1.27 1.03 - 1.51	1.82 1.56 - 2.08	2.10 1.43 - 2.78
60–79	542	4.24	1.30 1.07 - 1.53	0.97 0.83 - 1.14	0.41 <LOD - 0.56	0.63 0.51 - 0.74	1.00 0.78 - 1.21	1.53 1.35 - 1.72	2.35 1.99 - 2.71	2.99 2.33 - 3.65

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.1.6 Manganese (CASRN 7439-96-5)

Manganese (Mn) is a naturally occurring element that comprises approximately 0.1% of the Earth's crust and is considered to be one of the least toxic elements (Health Canada, 1987). Manganese is an essential nutrient required for the maintenance of human health (ATSDR, 2000). Pure manganese is silver in colour, but manganese in the environment is always found combined with other elements to form a variety of minerals. Manganese can exist in both organic and inorganic forms, with inorganic manganese in the Mn(II), Mn(III), or Mn(IV) oxidation states most often encountered in the environment and in the workplace. Organo-manganese compounds do not occur in nature, but are manufactured for specific uses (ATSDR, 2000).

Metallic manganese is used principally in steel production to improve hardness and strength. Other uses of manganese compounds include production of dry-cell batteries, fireworks, matches, animal feed (to supply essential trace minerals), porcelain and glass-bonding materials, and fertilizers. Potassium permanganate is commonly used in water and waste-treatment plants as a disinfectant and anti-algal agent, but is also used for metal cleaning, tanning, and bleaching (ATSDR, 2000).

The predominant use of organo-manganese compounds is in the form of methylcyclopentadienyl manganese tricarbonyl (MMT), an octane enhancer used by national petroleum refiners prior to 2004 (Health Canada, 2010). Other organo-manganese compounds, such as Maneb or Mancozeb, both of which are currently registered for use in Canada, are used as fungicides for fruits and vegetables, and in seed treatment. Another organo-manganese compound, mangafodipir, is used as a contrast agent in magnetic resonance imaging (MRI) (ATSDR, 2000).

Manganese is ubiquitous in the environment and is naturally occurring in air, soil, water, and biological organisms, including food. Manganese is released to the air from iron, steel, and power plants, from coke ovens, and in dust from mining operations. Food is the main source of manganese exposure for the majority of the population (ATSDR, 2000). Manganese is found in trace amounts in all plant and animal tissues. It is estimated that grain products contribute approximately 37% of manganese intake in the adult diet (IOM, 2001). Concentrations in food range from approximately 0.03 mg/kg in milk to approximately 43.9 mg/kg in wheat flour (Health Canada, 2007). The daily dietary intake of manganese for the Canadian population was estimated to be 56 μg/kg body weight/day in the last Canadian Total Diet Study carried out in 2002 (Health Canada, 2009).

The main routes of absorption for manganese are the respiratory and gastrointestinal tracts. Approximately 3–5% of orally ingested manganese is absorbed from the gastrointestinal tract and enters systemic circulation. Conversely, inhaled manganese enters systemic circulation directly, making the manganese available for distribution to and accumulation in the body's tissues, including the brain (Health Canada, 2008). The ubiquitous presence of manganese in foods along with the essential nature of this element has resulted in the development of homeostatic control mechanisms for dietary manganese. Under conditions of high dietary manganese, adaptive changes include reduced gastrointestinal absorption of manganese, enhanced manganese liver metabolism, and increased biliary and pancreatic excretion of manganese (Davis et al., 1993; Malecki et al., 1996; Finley and Davis, 1999; Dorman et al., 2001; Dorman et al., 2002). Biliary excretion is the main excretory pathway, and once manganese reaches the intestines, a large fraction of the element is ultimately excreted in the feces (Davis et al., 1993; Malecki et al., 1996). Urinary excretion of manganese is low and has been found to be relatively resistant to small changes in dietary manganese intake (Davis & Greger, 1992).

Concentrations in blood and urine can be used to evaluate exposure to manganese. Whole blood is preferred rather than plasma or serum since slight hemolysis of samples can have a significant effect on plasma or serum manganese concentrations (IOM, 2001). Concentrations in blood tend to reflect the overall body burden of manganese, while concentrations in urine are more commonly used to measure levels following an acute exposure to manganese as it is only responsive to significant fluctuations in manganese intake (IOM, 2001). The normal range of manganese concentrations is approximately 4 to 14 μg/L in whole blood, 0.15 to 2.65 μg/L in serum, and 0.97 to 1.07 μg/L in urine (ATSDR, 2000).

Manganese is an essential nutrient involved in the formation of bone, in cellular protection from free radical damage, and in amino acid, cholesterol, and carbohydrate metabolism (IOM, 2001; ATSDR, 2000). Health Canada (2005) has adopted Tolerable Upper Intake Levels (UL) developed by the Institute of Medicine (IOM) for manganese, which account for both its essentiality and its potential toxicity. The ULs for manganese are 2 mg/day for children 1–3 years old, 3 mg/day for children 4–8 years old, 6 mg/day for children 9–13 years old, 9 mg/day for adolescents 14–18 years old, and 11 mg/day for adults. The ULs for pregnant and lactating women are 9 mg/day for women 18 years or younger and 11 mg/day for women 19 years or older (IOM, 2001).

Manganese deficiency in humans is rare; however, excessive exposure to manganese can cause neurological effects (ATSDR, 2000). Very high concentrations of manganese in air, such as those associated with occupational exposures, can result in "metal fume fever," pneumonitis, and manganism (a condition resembling Parkinson's disease) (Health Canada, 1987). Exposure to moderately high levels of manganese in air can result in subtle neurological effects such as poorer fine motor skills. Health Canada has established a reference concentration of 0.05 μg/m^3 for manganese in air (Health Canada, 2010). Health Canada (1987) has established an aesthetic objective for drinking water of ≤0.05 mg/L based on palatability and staining of laundry and plumbing fixtures; this guideline was also deemed protective of adverse health effects. The World Health Organization (WHO) has established a health-based drinking water guideline for manganese of <0.4 mg/L (WHO, 2006).

The International Agency for Research on Cancer (IARC) has not published an evaluation of the carcinogenicity of manganese. The United States Environmental Protection Agency classified manganese as not classifiable as to human carcinogenicity based on an absence of human data and inadequate animal data (Group D) (US EPA, 1996).

In a study carried out in British Columbia, 61 non-smoking participants aged 30–65 were assessed for the levels of various trace elements in blood and urine. The geometric mean and 95th percentile values of manganese in blood were 10.75 μg/L and 14.94 μg/L, respectively (Clark et al., 2007). In a separate study carried out in the Québec City region, 500 participants aged 18–65 were assessed for the levels of various trace elements in blood and urine. The geometric mean and 90th percentile values of manganese in blood were 9.33 μg/L and 13.74 μg/L, respectively (INSPQ, 2004). In a study of manganese levels in a non-occupationally exposed adult population in Southwest Québec in 1996, blood samples were obtained from 297 subjects between the age of 20 and 69 years (Baldwin et al., 1999). The geometric mean blood manganese level for this population was 7.1 μg/L. A study investigating the link between manganese levels and convulsive disorders measured blood manganese levels in a reference population of 120 children (Dupont & Tanaka, 1985). Twenty-nine children, aged 2 to 17 years, were tested in 1976, and 24 children, aged 2 to 17 years, were tested in 1984. The mean blood manganese level for the 1976 reference population was 14.4 μg/L, while the mean for the 1984 reference population was 14.0 μg/L.

Manganese was measured in the blood and urine of all participants aged 6–79 years in the Canadian Health Measures Survey and is presented as μg/L in blood and as both μg/L and μg/g creatinine in urine (Tables 8.1.6a, 8.1.6b, 8.1.6c). Finding a measurable amount of manganese in blood or urine is an indicator of exposure to manganese and does not necessarily mean that an adverse health effect will occur. Because manganese is an essential nutrient for the maintenance of health, its presence is expected. These data provide reference ranges for blood and urinary levels of manganese in the Canadian population.

Table 8.1.6a

Manganese – Arithmetic and geometric means, and selected percentiles of blood concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5309	0.00	9.68 9.43 - 9.94	9.22 8.99 - 9.47	6.34 6.11 - 6.58	7.49 7.29 - 7.70	9.04 8.81 - 9.27	11.19 10.89 - 11.49	13.71 13.18 - 14.24	15.63 14.98 - 16.27
6–11	907	0.00	10.28 9.99 - 10.58	9.86 9.59 - 10.14	6.94 6.67 - 7.20	8.08 7.76 - 8.40	9.74 9.38 - 10.10	11.82 11.43 - 12.21	14.14 13.42 - 14.86	16.36 15.49 - 17.22
12–19	942	0.00	10.44 10.13 - 10.75	9.97 9.71 - 10.24	6.68 6.44 - 6.93	8.03 7.75 - 8.30	9.96 9.49 - 10.42	12.20 11.51 - 12.88	14.91 14.32 - 15.51	16.31 15.74 - 16.89
20–39	1162	0.00	9.66 9.28 - 10.04	9.17 8.84 - 9.51	6.27 6.03 - 6.52	7.45 7.14 - 7.75	9.00 8.67 - 9.32	11.22 10.87 - 11.58	13.99 12.91 - 15.06	16.09 14.67 - 17.50
40–59	1219	0.00	9.56 9.15 - 9.97	9.13 8.78 - 9.49	6.42 6.07 - 6.76	7.50 7.22 - 7.79	8.90 8.54 - 9.26	10.83 10.51 - 11.14	13.54 12.81 - 14.27	15.28 14.02 - 16.54
60–79	1079	0.00	9.27 9.01 - 9.54	8.83 8.56 - 9.11	5.96 5.55 - 6.37	7.15 7.00 - 7.29	8.82 8.42 - 9.23	10.82 10.43 - 11.22	12.75 12.14 - 13.36	14.30 13.59 - 15.02
Males										
Total, age 6–79	2572	0.00	9.17 8.88 - 9.45	8.77 8.51 - 9.04	6.15 5.83 - 6.48	7.20 6.94 - 7.46	8.66 8.36 - 8.96	10.58 10.18 - 10.97	12.83 12.14 - 13.53	14.20 13.47 - 14.92
6–11	458	0.00	9.88 9.40 - 10.36	9.46 9.06 - 9.88	6.59 6.09 - 7.10	7.65 7.22 - 8.09	9.35 8.93 - 9.77	11.63 11.03 - 12.23	13.56 12.08 - 15.05	15.44 13.11 - 17.77
12–19	489	0.00	9.81 9.30 - 10.31	9.44 8.99 - 9.90	6.46 6.16 - 6.76	7.77 7.40 - 8.14	9.43 8.91 - 9.94	11.43 10.34 - 12.51	13.57 12.57 - 14.56	14.71 13.89 - 15.54
20–39	511	0.00	8.96 8.67 - 9.25	8.60 8.31 - 8.89	6.21 5.90 - 6.51	7.12 6.67 - 7.58	8.42 8.02 - 8.82	10.34 9.78 - 10.90	12.43 11.34 - 13.53	13.45 12.17 - 14.74
40–59	577	0.00	9.15 8.71 - 9.59	8.77 8.39 - 9.16	6.27 5.61 - 6.93	7.31 6.86 - 7.77	8.69 8.22 - 9.15	10.38 9.92 - 10.83	12.35 11.29 - 13.41	13.97 12.63 - 15.31
60–79	537	0.00	8.87 8.48 - 9.25	8.41 8.06 - 8.78	5.65 5.40 - 5.91	6.79 6.58 - 7.00	8.23 7.75 - 8.72	10.29 9.62 - 10.96	12.50 11.61 - 13.38	14.18 13.36 - 15.00
Females										
Total, age 6–79	2737	0.00	10.21 9.93 - 10.49	9.70 9.44 - 9.96	6.62 6.40 - 6.84	7.80 7.54 - 8.06	9.55 9.22 - 9.88	11.75 11.45 - 12.05	14.75 13.90 - 15.59	16.48 15.48 - 17.48
6–11	449	0.00	10.71 10.40 - 11.03	10.31 10.00 - 10.62	7.38 6.91 - 7.84	8.54 8.23 - 8.85	10.16 9.64 - 10.69	12.17 11.60 - 12.73	14.73 13.62 - 15.85	16.43 15.55 - 17.31
12–19	453	0.00	11.15 10.84 - 11.45	10.60 10.35 - 10.86	7.17 6.65 - 7.69	8.33 7.99 - 8.67	10.78 10.33 - 11.24	13.22 12.10 - 14.33	16.10 15.45 - 16.75	17.28 16.33 - 18.24
20–39	651	0.00	10.38 9.67 - 11.09	9.79 9.20 - 10.42	6.61 6.11 - 7.12	7.79 7.26 - 8.32	9.49 8.84 - 10.14	11.97 11.23 - 12.72	15.80 13.89 - 17.72	17.32 15.24 - 19.40
40–59	642	0.00	9.98 9.39 - 10.56	9.50 9.03 - 10.00	6.50 6.13 - 6.87	7.73 7.36 - 8.10	9.21 8.61 - 9.81	11.53 10.92 - 12.13	14.08 12.57 - 15.59	16.23 13.66 - 18.81
60–79	542	0.00	9.64 9.40 - 9.89	9.23 9.00 - 9.46	6.59 6.30 - 6.88	7.61 7.36 - 7.86	9.39 9.00 - 9.77	11.03 10.63 - 11.43	12.91 12.27 - 13.55	14.34 13.57 - 15.11

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated

Table 8.1.6b

Manganese – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5431	35.54	0.15 0.12 - 0.18	0.08 0.07 - 0.09	<LOD	<LOD	0.08 0.07 - 0.10	0.16 0.14 - 0.19	0.29 0.24 - 0.35	0.40 0.34 - 0.47
6–11	1032	38.08	0.25 0.08 - 0.43	0.08 0.07 - 0.09	<LOD	<LOD	0.08 0.07 - 0.09	0.17 0.14 - 0.20	0.30 0.26 - 0.35	0.45 0.36 - 0.54
12–19	981	32.31	0.17 0.12 - 0.22	0.09 0.08 - 0.10	<LOD	<LOD	0.09 0.08 - 0.10	0.17 0.14 - 0.19	0.29 0.22 - 0.36	0.41 0.34 - 0.48
20–39	1153	38.16	0.13 0.11 - 0.15	0.08 0.07 - 0.09	<LOD	<LOD	0.08 0.07 - 0.09	0.16 0.13 - 0.20	0.31 0.23 - 0.39	0.42 0.33 - 0.51
40–59	1203	35.91	0.14 0.11 - 0.17	0.08 0.07 - 0.09	<LOD	<LOD	0.08 0.07 - 0.10	0.16 0.12 - 0.19	0.28 0.21 - 0.35	0.38 0.31 - 0.45
60–79	1062	32.77	0.16 0.13 - 0.18	0.08 0.07 - 0.09	<LOD	<LOD	0.08 0.07 - 0.09	0.17 0.13 - 0.20	0.29 0.25 - 0.34	0.42 0.33 - 0.51
Males										
Total, age 6–79	2639	38.16	0.15 0.11 - 0.19	0.08 0.07 - 0.09	<LOD	<LOD	0.08 0.07 - 0.09	0.15 0.12 - 0.19	0.28 0.21 - 0.34	0.39 0.29 - 0.48
6–11	524	39.89	0.35 <LOD - 0.67	0.08 0.07 - 0.09	<LOD	<LOD	0.08 0.07 - 0.09	0.14 0.11 - 0.18	0.28 0.20 - 0.36	0.39 0.26 - 0.51
12–19	505	35.25	0.16 0.10 - 0.22	0.08 0.07 - 0.09	<LOD	<LOD	0.08 0.07 - 0.10	0.15 0.13 - 0.18	0.26 0.20 - 0.33	0.39 0.29 - 0.49
20–39	510	40.20	—	—	<LOD	<LOD	0.08 0.06 - 0.10	0.16 0.11 - 0.21	0.33 0.21 - 0.45	0.46 0.30 - 0.63
40–59	572	38.64	0.12 0.09 - 0.15	0.08 0.06 - 0.09	<LOD	<LOD	0.08 0.06 - 0.10	0.15 0.12 - 0.19	0.26 0.19 - 0.32	0.37 0.25 - 0.48
60–79	528	36.74	0.12 0.09 - 0.15	0.07 0.06 - 0.09	<LOD	<LOD	0.08 0.06 - 0.10	0.15 0.10 - 0.20	0.26 0.20 - 0.32	0.37 0.22 - 0.51
Females										
Total, age 6–79	2792	33.06	0.15 0.13 - 0.18	0.08 0.07 - 0.09	<LOD	<LOD	0.09 0.08 - 0.10	0.17 0.15 - 0.19	0.30 0.25 - 0.35	0.41 0.37 - 0.45
6–11	508	36.22	0.15 0.12 - 0.18	0.08 0.07 - 0.10	<LOD	<LOD	0.09 0.06 - 0.11	0.18 0.15 - 0.22	0.32 0.24 - 0.39	0.45 0.37 - 0.53
12–19	476	29.20	0.18 0.10 - 0.26	0.10 0.09 - 0.11	<LOD	<LOD	0.10 0.09 - 0.12	0.19 0.16 - 0.22	0.31 0.22 - 0.41	0.42 0.33 - 0.50
20–39	643	36.55	0.13 0.11 - 0.15	0.08 0.07 - 0.09	<LOD	<LOD	0.08 0.06 - 0.10	0.17 0.13 - 0.20	0.27 0.19 - 0.35	0.40 0.32 - 0.47
40–59	631	33.44	0.15 0.11 - 0.19	0.08 0.07 - 0.10	<LOD	<LOD	0.09 0.07 - 0.11	0.16 0.12 - 0.21	0.31 0.24 - 0.38	0.40 0.33 - 0.48
60–79	534	28.84	0.19 0.14 - 0.24	0.09 0.08 - 0.10	<LOD	<LOD	0.09 0.07 - 0.11	0.18 0.15 - 0.21	0.31 0.25 - 0.37	0.44 0.31 - 0.58

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.6c

Manganese (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5418	35.62	0.22 0.18 - 0.26	0.10 0.09 - 0.11	<LOD	<LOD	0.09 0.08 - 0.10	0.19 0.16 - 0.23	0.39 0.31 - 0.48	0.70 0.57 - 0.84
6–11	1029	38.19	0.39 0.28 - 0.49	0.12 0.11 - 0.14	<LOD	<LOD	0.11 0.09 - 0.13	0.23 0.19 - 0.28	0.51 0.41 - 0.61	0.82 0.66 - 0.98
12–19	980	32.35	0.18 0.11 - 0.26	0.08 0.06 - 0.09	<LOD	<LOD	0.07 0.06 - 0.09	0.14 0.11 - 0.17	0.27 0.20 - 0.35	0.49 0.32 - 0.67
20–39	1149	38.29	0.19 0.14 - 0.25	0.09 0.07 - 0.10	<LOD	<LOD	0.08 0.07 - 0.09	0.18 0.13 - 0.22	0.34 0.24 - 0.44	0.62 0.38 - 0.85
40–59	1198	36.06	0.21 0.16 - 0.25	0.10 0.09 - 0.12	<LOD	<LOD	0.09 0.08 - 0.11	0.20 0.15 - 0.25	0.43 0.29 - 0.58	0.78 0.57 - 1.00
60–79	1062	32.77	0.24 0.20 - 0.27	0.11 0.10 - 0.13	<LOD	<LOD	0.11 0.10 - 0.12	0.23 0.22 - 0.25	0.44 0.34 - 0.54	0.77 0.62 - 0.91
Males										
Total, age 6–79	2630	38.29	0.17 0.13 - 0.21	0.08 0.07 - 0.09	<LOD	<LOD	0.07 0.06 - 0.08	0.14 0.11 - 0.18	0.28 0.23 - 0.33	0.48 0.34 - 0.63
6–11	522	40.04	—	—	<LOD	<LOD	0.10 0.08 - 0.12	0.21 0.16 - 0.26	0.47 0.33 - 0.62	0.74 0.50 - 0.98
12–19	504	35.32	0.16 0.09 - 0.23	0.07 0.06 - 0.08	<LOD	<LOD	0.06 0.05 - 0.08	0.12 0.10 - 0.14	0.23 0.18 - 0.28	0.31 0.16 - 0.47
20–39	508	40.35	—	—	<LOD	<LOD	0.07 0.06 - 0.09	0.14 0.08 - 0.20	0.29 0.19 - 0.38	0.43 0.22 - 0.63
40–59	568	38.91	0.16 0.11 - 0.21	0.08 0.06 - 0.09	<LOD	<LOD	0.07 0.05 - 0.09	0.14 0.10 - 0.18	0.27 0.21 - 0.33	0.55 0.23 - 0.86
60–79	528	36.74	0.13 0.10 - 0.17	0.08 0.06 - 0.10	<LOD	<LOD	0.07 0.06 - 0.09	0.15 0.11 - 0.20	0.31 0.24 - 0.38	0.44 0.32 - 0.56
Females										
Total, age 6–79	2788	33.11	0.27 0.21 - 0.32	0.12 0.11 - 0.14	<LOD	<LOD	0.12 0.11 - 0.13	0.24 0.21 - 0.27	0.50 0.40 - 0.61	0.85 0.70 - 0.99
6–11	507	36.29	0.32 0.26 - 0.39	0.13 0.11 - 0.15	<LOD	<LOD	0.12 0.10 - 0.14	0.27 0.21 - 0.32	0.55 0.42 - 0.67	0.85 0.66 - 1.05
12–19	476	29.20	0.21 0.09 - 0.33	0.09 0.07 - 0.11	<LOD	<LOD	0.08 0.06 - 0.10	0.16 0.11 - 0.20	0.41 0.30 - 0.52	0.62 0.43 - 0.81
20–39	641	36.66	0.25 0.15 - 0.36	0.11 0.09 - 0.13	<LOD	<LOD	0.10 0.09 - 0.12	0.22 0.16 - 0.27	0.41 0.25 - 0.57	0.73 0.21 - 1.24
40–59	630	33.49	0.26 0.20 - 0.32	0.14 0.12 - 0.16	<LOD	<LOD	0.12 0.10 - 0.15	0.26 0.20 - 0.32	0.54 0.40 - 0.68	0.87 0.70 - 1.04
60–79	534	28.84	0.33 0.26 - 0.39	0.16 0.13 - 0.19	<LOD	<LOD	0.15 0.12 - 0.19	0.28 0.23 - 0.32	0.68 0.45 - 0.91	1.08 0.55 - 1.62

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.1.7 Mercury (CASRN 7439-97-6)

Mercury (Hg) is a naturally occurring soft, silver-white metal; it is the only metal that is a liquid at room temperature. Its liquid state has a very wide temperature range. It has a relatively high vapour pressure; as a result, it can be present at hazardous concentrations in air as a vapour. Mercury exists in elemental, inorganic, and organic forms (CCME, 1996). The most common organic mercury compounds in nature are methylmercury (monomethylmercury) and dimethylmercury. Mercury can be converted between its elemental, inorganic, and organic forms by a variety of processes, including biological transformation (CCME, 1996; Environment Canada, 2007a).

Use of mercury in consumer products has been limited. Mercury was used in certain products where its unique properties were useful, such as relays and switches, and scientific measuring devices (e.g., flame sensors for older gas-fired appliances, vacuum gauges, thermometers), but it has been phased out of most products, including thermometers and switches. It is still used in some medical devices and some dental fillings (amalgam). Use of mercury in button-cell batteries, which are commonly used in small electronic and hearing aids, has been greatly reduced in recent years (Environment Canada, 2007b).

Mercury is present in many lamps and lights, including all fluorescent lamps, mercury vapour lamps (also known as high intensity discharge or HID lamps), metal halide lamps, and sodium vapour lamps (Environment Canada, 2007a). Use of mercury in light bulbs is increasing because of widespread replacement of incandescent bulbs with compact fluorescent bulbs. Mercury is also used in laboratory reagents and as industrial catalysts. It is used in pharmaceuticals, disinfectants, and embalming solutions. Historically, it was used as an antimicrobial and preservative in paints and in some agricultural applications, including turf fungicides, but these practices have been mostly discontinued. A significant use of inorganic mercury is in dental amalgam; in Canada, dental amalgam is made up of 43–50.5% mercury, but it contributes only a small amount to the total daily exposure of Canadians to mercury (CCME, 1996; Environment Canada, 2007a).

Mercury is found throughout the environment, including in remote Arctic regions, due to its persistence, mobility, and tendency to accumulate in colder climates, although it is uncertain how much is natural and how much is anthropogenic. Anthropogenic sources of inorganic mercury in the environment include metal mining and smelting; combustion of fossil fuels, particularly coal; incineration of municipal wastes; cement production; and sewage sludge and wastewater (CCME, 1996; UNEP, 2002). Inorganic mercury may also be released to the environment following disposal of products containing mercury. Metabolism of inorganic mercury by micro-organisms in the environment creates organic mercury (methylmercury), which can bioaccumulate in terrestrial and aquatic food chains (ATSDR, 1999).

Exposure of the general population is primarily to methylmercury and occurs through the consumption of contaminated fish and seafood (Health Canada, 2007). To a much lesser extent, the general population is exposed to inorganic mercury from sources such as dental amalgams (Health Canada, 2007). Previous studies have shown that inorganic mercury comprises 14–26% of total blood mercury (Kingman et al., 1998; Passos et al., 2007; Oskarsson et al., 1996).

Approximately 95% of organic mercury is absorbed from the gastrointestinal tract following oral ingestion. Following absorption, organic mercury is distributed to all tissues, including hair, with highest accumulation in the kidneys (ATSDR, 1999). Organic mercury is de-methylated in the body to inorganic mercury, which accumulates primarily in the liver and kidneys. Methylmercury is estimated to have a biological half-life of approximately 50 days. The majority of mercury in the body is excreted via the feces, with a small amount excreted as inorganic mercury in the urine (ATSDR, 1999).

Exposure to mercury is commonly evaluated using mercury concentrations in blood and urine, although hair may also be used as a biomarker of mercury exposure (ATSDR, 1999). Typically, blood and urine mercury levels are reported as total mercury, which comprises both inorganic and organic mercury. The concentration of total mercury in blood is accepted as a reasonable biomeasure of methyl mercury exposure. Based on a review of existing data from other countries, the World Health Organization has estimated that the average total blood mercury concentration for the general population is approximately 8 µg/L; however, individuals with high fish consumption can have concentrations in blood as high as 200 µg/L (ATSDR, 1999). Typical total mercury concentrations in urine have been reported to be in the 4 to 5 µg/L range. Both blood and urine concentrations primarily reflect recent exposures to mercury; urinary mercury levels are also commonly used for assessment of long-term exposure to inorganic mercury (ATSDR, 1999).

Mercury is known to be toxic to both humans and the environment. The toxic effects of mercury depend on the form and the exposure route. Exposure to low concentrations or doses may not result in any observable symptoms (Health Canada, 2007). Inhalation of mercury vapour may cause respiratory, cardiovascular, kidney, and neurological effects. Exposure to elemental mercury is hazardous because of its potential release of toxic mercury vapour, which is readily absorbed into the body through inhalation. Elemental mercury is poorly absorbed through the digestive tract or the skin (ATSDR, 1999). Low-level exposure to inorganic mercury from dental amalgams has not been associated with neurologic effects in children or adults (Bates et al., 2004; Bellinger et al., 2007; DeRouen et al., 2006; Factor-Litvak et al., 2003).

The primary effects associated with oral exposure to organic mercury compounds are neurological effects and developmental neurotoxicity; effects are similar for both acute and chronic exposure. Symptoms of organic mercury toxicity include a tingling sensation in the extremities; impaired peripheral vision, hearing, taste, and smell; slurred speech; muscle weakness and an unsteady gait; irritability; memory loss; depression; and sleeping difficulties. Exposure of a fetus or young child to organic mercury can result in effects on the development of the nervous system, affecting fine motor function, attention, verbal learning, and memory (ATSDR, 1999; Health Canada, 2007).

The United Nations Environment Programme (UNEP) completed a global risk assessment for mercury, and concluded that there was "sufficient evidence of adverse impacts from mercury to warrant further international action to reduce the risks to human health and the environment" (UNEP, 2002). In Canada, several Canada-wide standards have been established to reduce the releases of mercury to the environment (CCME, 2005; Environment Canada, 2007a). The Surface Coating Materials Regulations, in effect under the *Hazardous Products Act* since April 2005, restrict the level of mercury to no more than 10 mg/kg in all surface coating materials advertised, sold, or imported into Canada (Health Canada, 2006). Mercury is controlled in a number of other products used by Canadians. For example, mercury is listed on the Cosmetic Ingredient Hotlist. The *Food and Drug Regulations* prohibit the use of mercury in most drugs. Under the *Pest Control Products Act*, mercury-based pesticides are not registered for use in Canada and the mercury levels in natural health products are also restricted.

The International Agency for Research on Cancer (IARC, 1993) determined that methylmercury compounds are possible human carcinogens (Group 2B), based on inadequate human data but sufficient animal data showing a link to certain cancers, particularly renal cancer. Metallic mercury and inorganic mercury compounds were determined to be not classifiable as to their carcinogenicity (Group 3B) (IARC, 1993).

Health Canada (2007) has adopted a provisional tolerable daily intake for mercury developed by the World Health Organization of 0.71 μg/kg body weight/day for adults, of which no more than 2/3 (0.47 μg/kg body weight/day) should be methylmercury, as well as a provisional tolerable weekly intake of 1.6 μg methylmercury/kg body weight/week for women who are or may become pregnant and for young children; exposures below these doses are not expected to result in adverse health effects. Health Canada (2004) has established a total mercury blood guidance value of 20 μg/L for the general adult population; a revised guidance value of 8 μg/L for children, pregnant women, and women of childbearing age has recently been recommended (Legrand et al., 2010). Health Canada (1986) established a maximum acceptable concentration of 0.001 mg/L (1 μg/L) for mercury in drinking water. In addition, the Food Directorate of Health Canada has established a guideline level of 0.5 parts per million (ppm) for total mercury in domestically produced and imported fish considered to be the major source of dietary exposure (Health Canada, 2004).

In a study carried out in British Columbia to assess the levels of trace elements in 61 non-smoking adults aged 30–65, the geometric mean and 95th percentile concentrations of total mercury in blood were 2.94 μg/L and 7.26 μg/L, respectively (Clark et al., 2007). In a separate study carried out in the region of Québec City, on 500 adults aged 18–65, the geometric mean and 90th percentile concentrations of total mercury in blood were 0.74 μg/L and 2.01 μg/L, respectively (INSPQ, 2004).

Total and inorganic mercury were measured in the blood and urine of all participants aged 6–79 years in the Canadian Health Measures Survey. Total mercury is presented as μg/L in blood, and inorganic mercury is presented as μg/L in blood and both μg/L and μg/g creatinine in urine (Tables 8.1.7a, 8.1.7b, 8.1.7c, 8.1.7d). Finding a measurable amount of mercury in blood or urine is an indicator of exposure to mercury and does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for blood and urinary levels of total and inorganic mercury in the Canadian population.

Table 8.1.7a

Mercury (Total) – Arithmetic and geometric means, and selected percentiles of blood concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5319	11.64	1.42 1.00 - 1.84	0.69 0.56 - 0.86	0.12 <LOD - 0.14	0.33 0.26 - 0.39	0.81 0.64 - 0.97	1.61 1.17 - 2.04	3.07 2.21 - 3.93	4.70 2.61 - 6.78
6–11	910	24.84	0.58 0.44 - 0.73	0.27 0.22 - 0.32	<LOD	<LOD	0.28 0.23 - 0.34	0.66 0.47 - 0.85	1.37 1.07 - 1.67	2.08 1.27 - 2.88
12–19	945	20.85	0.64 0.31 - 0.97	0.31 0.23 - 0.40	<LOD	0.13 <LOD - 0.18	0.32 0.24 - 0.41	0.76 0.47 - 1.06	1.36 0.53 - 2.20	2.25 0.93 - 3.56
20–39	1165	8.76	1.28 0.87 - 1.69	0.65 0.52 - 0.82	0.12 <LOD - 0.16	0.30 0.24 - 0.36	0.77 0.62 - 0.92	1.49 0.93 - 2.06	3.10 1.97 - 4.24	4.89 2.45 - 7.32
40–59	1220	3.52	1.88 1.28 - 2.49	1.02 0.81 - 1.27	0.27 0.19 - 0.35	0.56 0.42 - 0.70	1.11 0.86 - 1.37	1.93 1.50 - 2.36	3.59 2.31 - 4.86	6.39 3.03 - 9.76
60–79	1079	4.73	1.55 1.05 - 2.06	0.87 0.66 - 1.16	0.17 <LOD - 0.26	0.47 0.33 - 0.61	0.97 0.70 - 1.23	1.89 1.23 - 2.54	3.41 2.43 - 4.38	4.83 2.73 - 6.92
Males										
Total, age 6–79	2576	12.11	1.50 0.99 - 2.00	0.68 0.55 - 0.85	0.10 <LOD - 0.14	0.32 0.25 - 0.39	0.79 0.64 - 0.94	1.61 1.15 - 2.07	3.16 2.18 - 4.15	5.13 2.70 - 7.57
6–11	459	26.14	0.51 0.32 - 0.71	0.24 0.19 - 0.31	<LOD	<LOD	0.26 0.18 - 0.33	0.62 0.39 - 0.84	1.19 0.52 - 1.86	2.05 0.96 - 3.13
12–19	489	20.65	0.65 0.15 - 1.16	0.29 0.20 - 0.41	<LOD	0.12 <LOD - 0.17	0.28 0.17 - 0.39	0.64 0.19 - 1.09	1.48 0.41 - 2.55	2.29 0.54 - 4.04
20–39	514	9.34	1.26 0.82 - 1.70	0.62 0.47 - 0.80	<LOD	0.27 0.19 - 0.36	0.73 0.56 - 0.90	1.51 0.72 - 2.30	3.18 1.71 - 4.65	4.61 2.60 - 6.63
40–59	577	3.47	2.08 1.12 - 3.03	1.04 0.82 - 1.32	0.28 0.19 - 0.37	0.59 0.43 - 0.75	1.07 0.81 - 1.32	1.83 1.52 - 2.15	3.42 1.28 - 5.56	6.84 1.42 - 12.26
60–79	537	4.28	1.73 1.09 - 2.37	0.98 0.73 - 1.31	0.21 0.10 - 0.31	0.51 0.37 - 0.66	1.05 0.69 - 1.40	2.20 1.61 - 2.79	3.57 1.80 - 5.34	5.67 1.35 - 9.99
Females										
Total, age 6–79	2743	11.19	1.34 0.96 - 1.72	0.70 0.56 - 0.89	0.13 0.10 - 0.16	0.33 0.25 - 0.40	0.83 0.63 - 1.03	1.58 1.15 - 2.00	3.00 2.14 - 3.87	4.45 2.55 - 6.36
6–11	451	23.50	0.66 0.53 - 0.79	0.29 0.25 - 0.35	<LOD	0.11 <LOD - 0.15	0.30 0.25 - 0.34	0.80 0.54 - 1.05	1.44 1.21 - 1.67	2.15 1.08 - 3.23
12–19	456	21.05	0.63 0.46 - 0.79	0.33 0.26 - 0.42	<LOD	0.15 <LOD - 0.21	0.36 0.27 - 0.45	0.83 0.60 - 1.05	1.19 0.43 - 1.96	2.23 1.32 - 3.15
20–39	651	8.29	1.30 0.85 - 1.76	0.70 0.52 - 0.92	0.16 0.10 - 0.22	0.33 0.23 - 0.42	0.80 0.59 - 1.02	1.49 0.96 - 2.02	2.67 1.69 - 3.65	4.77 2.07 - 7.46
40–59	643	3.58	1.69 1.19 - 2.20	0.99 0.77 - 1.28	0.24 0.14 - 0.34	0.53 0.36 - 0.69	1.16 0.88 - 1.44	2.02 1.44 - 2.60	3.65 2.21 - 5.10	5.35 2.02 - 8.67
60–79	542	5.17	1.39 0.99 - 1.80	0.79 0.59 - 1.05	0.13 <LOD - 0.22	0.40 0.21 - 0.58	0.92 0.71 - 1.12	1.70 1.20 - 2.19	3.33 2.47 - 4.19	4.37 2.97 - 5.77

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.7b

Mercury (inorganic) – Arithmetic and geometric means, and selected percentiles of blood concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	1123	88.16	—	—	<LOD	<LOD	<LOD	<LOD	0.56 <LOD - 0.73	0.88 0.41 - 1.36
6–11	221	96.38	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
12–19	204	98.04	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	247	88.66	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.75 0.63 - 0.86
40–59	253	79.05	—	—	<LOD	<LOD	<LOD	<LOD	0.77 <LOD - 1.25	1.43 0.54 - 2.32
60–79	198	79.80	—	—	<LOD	<LOD	<LOD	<LOD	0.92 0.43 - 1.41	S
Males										
Total, age 6–79	557	88.87	—	—	<LOD	<LOD	<LOD	<LOD	0.49 <LOD - 0.75	0.88 <LOD - 1.51
6–11	110	95.45	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	S
12–19	117	98.29	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	S
20–39	113	92.92	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	S
40–59	115	81.74	—	—	<LOD	<LOD	<LOD	<LOD	0.80 <LOD - 1.52	S
60–79	102	74.51	—	—	<LOD	<LOD	<LOD	<LOD <LOD - 0.61	0.92 <LOD - 1.48	S
Females										
Total, age 6–79	566	87.46	—	—	<LOD	<LOD	<LOD	<LOD	0.60 0.42 - 0.77	0.88 0.48 - 1.27
6–11	111	97.30	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	S
12–19	87	97.70	—	—	S	<LOD	<LOD	<LOD	S	S
20–39	134	85.07	—	—	<LOD	<LOD	<LOD	<LOD	0.58 <LOD - 0.93	S
40–59	138	76.81	—	—	<LOD	<LOD	<LOD	<LOD	0.75 0.41 - 1.10	S
60–79	96	85.42	—	—	S	<LOD	<LOD	<LOD	S	S

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

S Any estimate based on fewer than the minimum number of respondents required according to the *Statistics Act* must be suppressed in order to ensure respondent confidentiality. See Section 6.0, Statistical Data Analysis, for further information.

Table 8.1.7c

Mercury (inorganic) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5444	49.63	—	—	<LOD	<LOD	0.24 <LOD - 0.28	0.76 0.66 - 0.85	1.89 1.68 - 2.10	2.98 2.58 - 3.37
6–11	1028	66.05	—	—	<LOD	<LOD	<LOD	0.35 0.20 - 0.49	1.02 0.55 - 1.50	1.92 1.02 - 2.82
12–19	975	57.54	—	—	<LOD	<LOD	<LOD	0.43 0.32 - 0.55	1.20 0.76 - 1.64	2.32 1.52 - 3.11
20–39	1166	46.23	—	—	<LOD	<LOD	0.23 <LOD - 0.27	0.60 0.47 - 0.73	1.41 1.08 - 1.74	2.31 1.86 - 2.76
40–59	1207	36.04	0.94 0.69 - 1.19	0.31 0.26 - 0.37	<LOD	<LOD	0.38 0.29 - 0.47	1.03 0.79 - 1.27	2.55 1.86 - 3.23	3.50 2.23 - 4.77
60–79	1068	45.69	—	—	<LOD	<LOD	0.25 <LOD - 0.34	0.73 0.50 - 0.96	2.02 1.47 - 2.57	3.07 2.58 - 3.56
Males										
Total, age 6–79	2636	48.33	—	—	<LOD	<LOD	0.24 <LOD - 0.29	0.70 0.57 - 0.83	1.78 1.61 - 1.95	2.69 2.35 - 3.03
6–11	520	65.38	—	—	<LOD	<LOD	<LOD	0.33 <LOD - 0.52	0.95 0.38 - 1.51	1.95 0.81 - 3.10
12–19	501	57.09	—	—	<LOD	<LOD	<LOD	0.33 0.24 - 0.43	0.76 0.52 - 0.99	1.24 0.75 - 1.74
20–39	512	47.07	—	—	<LOD	<LOD	0.22 <LOD - 0.29	0.54 0.48 - 0.60	1.27 0.94 - 1.60	2.12 1.60 - 2.64
40–59	570	33.33	0.85 0.64 - 1.06	0.31 0.25 - 0.39	<LOD	<LOD	0.40 0.29 - 0.50	0.98 0.79 - 1.17	2.16 1.40 - 2.91	3.17 1.75 - 4.60
60–79	533	40.71	—	—	<LOD	<LOD	0.31 <LOD - 0.46	0.90 0.27 - 1.53	2.35 1.49 - 3.22	3.22 2.30 - 4.15
Females										
Total, age 6–79	2808	50.85	—	—	<LOD	<LOD	0.24 <LOD - 0.28	0.80 0.66 - 0.93	2.05 1.73 - 2.37	3.18 2.77 - 3.60
6–11	508	66.73	—	—	<LOD	<LOD	<LOD	0.36 <LOD - 0.55	1.09 0.56 - 1.61	1.81 0.74 - 2.87
12–19	474	58.02	—	—	<LOD	<LOD	<LOD	0.57 0.29 - 0.84	1.79 0.77 - 2.80	2.98 1.73 - 4.24
20–39	654	45.57	—	—	<LOD	<LOD	0.24 <LOD - 0.32	0.71 0.45 - 0.97	1.62 1.12 - 2.11	2.62 1.68 - 3.55
40–59	637	38.46	1.03 0.67 - 1.38	0.30 0.24 - 0.39	<LOD	<LOD	0.33 <LOD - 0.46	1.13 0.76 - 1.50	2.74 2.00 - 3.48	3.56 1.94 - 5.19
60–79	535	50.65	—	—	<LOD	<LOD	<LOD	0.63 0.48 - 0.79	1.76 1.20 - 2.33	2.74 2.12 - 3.36

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.7d

Mercury (inorganic) (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5432	49.74	—	—	<LOD	<LOD	0.26 <LOD - 0.30	0.73 0.62 - 0.83	1.67 1.50 - 1.84	2.56 2.16 - 2.97
6–11	1025	66.24	—	—	<LOD	<LOD	<LOD	0.48 0.32 - 0.63	1.31 0.60 - 2.02	2.01 1.33 - 2.69
12–19	975	57.54	—	—	<LOD	<LOD	<LOD	0.30 0.23 - 0.37	0.79 0.54 - 1.03	1.31 0.80 - 1.82
20–39	1162	46.39	—	—	<LOD	<LOD	0.22 <LOD - 0.25	0.55 0.44 - 0.67	1.16 0.92 - 1.39	1.93 1.56 - 2.30
40–59	1202	36.19	0.87 0.68 - 1.06	0.40 0.33 - 0.48	<LOD	<LOD	0.43 0.33 - 0.53	1.13 0.88 - 1.38	2.12 1.54 - 2.71	3.02 2.33 - 3.72
60–79	1068	45.69	—	—	<LOD	<LOD	0.30 <LOD - 0.43	0.94 0.68 - 1.20	2.05 1.77 - 2.33	2.77 2.15 - 3.38
Males										
Total, age 6–79	2628	48.48	—	—	<LOD	<LOD	0.22 <LOD - 0.27	0.57 0.50 - 0.64	1.25 1.09 - 1.41	1.80 1.49 - 2.11
6–11	518	65.64	—	—	<LOD	<LOD	<LOD	0.46 <LOD - 0.61	1.28 0.61 - 1.96	1.78 1.32 - 2.23
12–19	501	57.09	—	—	<LOD	<LOD	<LOD	0.24 <LOD - 0.30	0.54 0.28 - 0.81	0.91 0.73 - 1.09
20–39	510	47.25	—	—	<LOD	<LOD	<LOD <LOD - 0.23	0.40 0.34 - 0.46	0.77 0.57 - 0.97	1.15 0.90 - 1.39
40–59	566	33.57	0.66 0.50 - 0.82	0.31 0.24 - 0.40	<LOD	<LOD	0.37 0.26 - 0.48	0.85 0.60 - 1.10	1.53 1.00 - 2.07	2.57 1.52 - 3.63
60–79	533	40.71	—	—	<LOD	<LOD	0.27 <LOD - 0.44	0.93 0.47 - 1.40	1.76 1.31 - 2.21	2.35 1.47 - 3.22
Females										
Total, age 6–79	2804	50.93	—	—	<LOD	<LOD	0.30 <LOD - 0.36	0.93 0.76 - 1.11	2.11 1.79 - 2.43	2.91 2.30 - 3.52
6–11	507	66.86	—	—	<LOD	<LOD	<LOD	0.49 <LOD - 0.74	1.35 0.43 - 2.27	2.38 1.33 - 3.44
12–19	474	58.02	—	—	<LOD	<LOD	<LOD	0.39 0.23 - 0.55	1.18 0.49 - 1.87	2.31 0.89 - 3.73
20–39	652	45.71	—	—	<LOD	<LOD	0.26 <LOD - 0.33	0.72 0.54 - 0.90	1.79 1.27 - 2.31	2.51 1.77 - 3.26
40–59	636	38.52	1.08 0.77 - 1.38	0.51 0.42 - 0.62	<LOD	<LOD	0.55 <LOD - 0.68	1.34 1.04 - 1.64	2.57 2.01 - 3.14	3.67 1.90 - 5.45
60–79	535	50.65	—	—	<LOD	<LOD	<LOD	0.94 0.65 - 1.23	2.26 1.79 - 2.73	2.98 2.19 - 3.78

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.1.8 Molybdenum (CASRN 7439-98-7)

Molybdenum (Mo) is a naturally occurring element found throughout the Earth's crust, which commonly exists in combination with other elements and does not occur as a free metal in nature. It is classified as a heavy metal. Molybdenum can occur in a range of oxidation states from -2 to +6 (IMOA, 2007a). Molybdenum is an essential trace element required for the maintenance of good health (IOM, 2001; WHO, 2003).

Molybdenum is found naturally in soil, sediment, surface water, groundwater, plants, animals and humans. Anthropogenic sources of exposure include dust and fine particles produced during the refining or shaping of molybdenum or alloys containing molybdenum. Molybdenum may also be released to the environment through natural processes such as the weathering of soil. The primary use of molybdenum is in the steel industry as a component of steel alloys to increase strength and durability and aid in corrosion resistance (IMOA, 2007b). Other uses of molybdenum include electrical contacts, spark plugs, X-ray tubes, filaments, screens, and grids for radio valves, glass-to-metal seals, nonferrous alloys, and pigments (WHO, 1996). Molybdenum compounds are also used in agriculture for the treatment of seeds and in the formulation of fertilizers to prevent molybdenum deficiency (WHO, 2003).

Ingestion of food is a route of exposure for the general population (WHO, 2003). Absorption of dietary molybdenum from the gastrointestinal tract ranges from 30 to 70% (WHO, 1996). Following gastrointestinal absorption, molybdenum rapidly appears in the blood and most organs (WHO, 1996). The highest concentrations of molybdenum are found in the liver, kidneys, and bones, although there is no apparent bioaccumulation of molybdenum in human tissues. Molybdenum is primarily excreted in the urine; when molybdenum intake is low, approximately 60% of ingested molybdenum is excreted in the urine, but when molybdenum intake is high, over 90% is excreted in the urine (IOM, 2001; Turnlund et al., 1995).

Molybdenum is considered to be a nutritionally essential trace element in both animals and humans, as it helps to metabolize proteins and acts as a cofactor for several human enzymes (WHO, 2003; US EPA, 1993). The Recommended Dietary Allowance (RDA) is 45 µg/day for most adults, but 50 µg/day for pregnant and breastfeeding women (IOM, 2001). Average dietary intakes of molybdenum by adult men and women have been estimated at 109 and 76 µg/day, respectively. Molybdenum deficiency is normally only observed in people with metabolic defects (IOM, 2001).

Health Canada (2005) has adopted Tolerable Upper Intake Levels (UL) developed by the Institute of Medicine (IOM) for molybdenum, which account for both its essentiality and its potential toxicity. The ULs for molybdenum are 0.3 mg/day for children 1–3 years old, 0.6 mg/day for children 4–8 years old, 1.1 mg/day for children 9–13 years old, 1.7 mg/day for adolescents 14–18 years old, and 2 mg/day for adults. No UL was developed for infants 0–12 months old, but it is recommended that the sole source of intake is food and formula (IOM, 2001). There are limited toxicity data for molybdenum in humans since adverse effects observed in laboratory animals have not been observed in humans (IOM, 2001). However, chronic exposure to high levels of molybdenum has been associated with gout-like symptoms in humans, including high uric acid concentrations and joint pain (US EPA, 1993).

In a study undertaken in the region of Québec City, including 500 participants aged 18–65, the geometric mean and 90th percentile values for molybdenum in blood were 1.14 µg/L and 1.90 µg/L, respectively. In urine, the geometric mean and 90th percentile values were 44.25 µg/L and 115.16 µg/L, respectively (INSPQ, 2004). In a separate study carried out in British Columbia, which included 61 non-smoking adults aged 30–65, the geometric mean concentration and 90th percentile values for molybdenum in blood were 1.47 µg/L and 2.46 µg/L, respectively. The geometric mean and 95th percentile values in urine were 49.5 µg/g creatinine and 159.8 µg/g creatinine, respectively (Clark, 2007).

Molybdenum was measured in the blood and urine of all participants aged 6–79 years in the Canadian Health Measures Survey and is presented as µg/L in blood and both µg/L and µg/g creatinine in urine (Tables 8.1.8a, 8.1.8b, 8.1.8c). Finding a measurable amount of molybdenum in blood or urine is an indicator of exposure to molybdenum and does not necessarily mean that an adverse health effect will occur. Because molybdenum is an essential trace element required for the maintenance of health, its presence in the blood and urine is expected. These data provide reference ranges for blood and urinary levels of molybdenum in the Canadian population.

Table 8.1.8a

Molybdenum – Arithmetic and geometric means, and selected percentiles of blood concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5319	0.09	0.76 0.73 - 0.79	0.67 0.66 - 0.69	0.40 0.39 - 0.42	0.51 0.50 - 0.53	0.66 0.64 - 0.68	0.86 0.83 - 0.89	1.16 1.11 - 1.21	1.38 1.31 - 1.46
6–11	910	0.00	1.09 0.75 - 1.43	0.85 0.83 - 0.87	0.57 0.55 - 0.59	0.66 0.65 - 0.68	0.80 0.76 - 0.84	1.05 0.98 - 1.12	1.35 1.31 - 1.39	1.60 1.51 - 1.69
12–19	945	0.11	0.75 0.69 - 0.80	0.68 0.63 - 0.72	0.41 0.38 - 0.44	0.52 0.49 - 0.55	0.65 0.60 - 0.71	0.85 0.79 - 0.92	1.10 1.00 - 1.19	1.31 1.10 - 1.52
20–39	1165	0.09	0.72 0.69 - 0.76	0.65 0.63 - 0.68	0.40 0.37 - 0.44	0.49 0.47 - 0.51	0.64 0.60 - 0.67	0.82 0.77 - 0.87	1.11 0.96 - 1.25	1.38 1.22 - 1.53
40–59	1220	0.08	0.70 0.67 - 0.73	0.64 0.61 - 0.67	0.38 0.34 - 0.41	0.49 0.47 - 0.52	0.64 0.60 - 0.67	0.81 0.75 - 0.87	1.08 1.01 - 1.14	1.24 1.17 - 1.30
60–79	1079	0.19	0.83 0.80 - 0.87	0.73 0.71 - 0.75	0.41 0.38 - 0.45	0.55 0.51 - 0.58	0.72 0.70 - 0.74	0.93 0.90 - 0.97	1.31 1.23 - 1.38	1.64 1.47 - 1.81
Males										
Total, age 6–79	2576	0.12	0.76 0.71 - 0.81	0.67 0.65 - 0.68	0.41 0.39 - 0.42	0.50 0.49 - 0.51	0.65 0.64 - 0.67	0.85 0.81 - 0.88	1.12 1.04 - 1.19	1.35 1.24 - 1.46
6–11	459	0.00	1.27 0.59 - 1.96	0.87 0.84 - 0.90	0.57 0.53 - 0.61	0.68 0.65 - 0.71	0.82 0.74 - 0.89	1.06 0.96 - 1.16	1.35 1.30 - 1.41	1.59 1.50 - 1.68
12–19	489	0.00	0.77 0.70 - 0.84	0.70 0.65 - 0.74	0.43 0.39 - 0.48	0.54 0.51 - 0.58	0.67 0.62 - 0.71	0.87 0.81 - 0.93	1.12 0.99 - 1.24	1.35 0.98 - 1.72
20–39	514	0.00	0.69 0.65 - 0.74	0.64 0.61 - 0.67	0.41 0.36 - 0.45	0.49 0.46 - 0.51	0.63 0.59 - 0.67	0.80 0.75 - 0.85	1.03 0.85 - 1.21	1.30 1.08 - 1.52
40–59	577	0.17	0.70 0.65 - 0.74	0.63 0.60 - 0.67	0.38 0.33 - 0.43	0.48 0.44 - 0.52	0.64 0.59 - 0.68	0.80 0.73 - 0.86	1.04 0.97 - 1.10	1.21 1.11 - 1.30
60–79	537	0.37	0.79 0.74 - 0.84	0.69 0.65 - 0.74	0.40 0.36 - 0.44	0.51 0.46 - 0.57	0.69 0.64 - 0.73	0.90 0.85 - 0.95	1.21 1.11 - 1.32	1.55 1.36 - 1.74
Females										
Total, age 6–79	2743	0.07	0.76 0.74 - 0.79	0.68 0.66 - 0.71	0.40 0.37 - 0.43	0.52 0.50 - 0.55	0.67 0.65 - 0.70	0.88 0.83 - 0.92	1.19 1.14 - 1.24	1.40 1.31 - 1.49
6–11	451	0.00	0.89 0.84 - 0.94	0.83 0.80 - 0.86	0.56 0.53 - 0.59	0.65 0.62 - 0.67	0.78 0.74 - 0.81	1.03 0.96 - 1.09	1.34 1.22 - 1.46	1.60 1.37 - 1.84
12–19	456	0.22	0.72 0.67 - 0.78	0.65 0.60 - 0.71	0.39 0.35 - 0.43	0.49 0.45 - 0.53	0.63 0.55 - 0.71	0.83 0.72 - 0.94	1.09 0.98 - 1.19	1.26 1.13 - 1.39
20–39	651	0.15	0.75 0.69 - 0.81	0.67 0.64 - 0.71	0.40 0.35 - 0.44	0.51 0.48 - 0.54	0.64 0.61 - 0.68	0.85 0.78 - 0.92	1.19 0.99 - 1.39	1.42 1.17 - 1.68
40–59	643	0.00	0.70 0.66 - 0.74	0.64 0.60 - 0.68	0.37 0.33 - 0.42	0.50 0.46 - 0.54	0.64 0.60 - 0.68	0.82 0.75 - 0.90	1.11 1.00 - 1.22	1.26 1.16 - 1.35
60–79	542	0.00	0.88 0.82 - 0.93	0.77 0.74 - 0.80	0.44 0.39 - 0.50	0.58 0.55 - 0.62	0.75 0.72 - 0.78	0.99 0.93 - 1.05	1.33 1.28 - 1.38	1.64 1.48 - 1.81

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.8b

Molybdenum – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5492	0.00	53.08 49.50 - 56.66	36.30 33.20 - 39.68	10.12 8.58 - 11.65	20.21 17.18 - 23.23	40.41 37.51 - 43.31	70.60 66.71 - 74.48	107.80 99.90 - 115.69	138.28 128.01 - 148.55
6–11	1034	0.00	75.52 68.90 - 82.13	56.46 50.21 - 63.48	19.42 15.14 - 23.69	34.83 30.05 - 39.61	60.31 52.12 - 68.49	101.86 94.18 - 109.54	146.49 134.78 - 158.20	174.11 161.10 - 187.11
12–19	983	0.00	74.32 65.34 - 83.29	53.74 46.47 - 62.15	15.42 11.25 - 19.59	33.18 24.49 - 41.87	62.96 55.38 - 70.54	100.18 88.69 - 111.67	134.76 119.78 - 149.75	172.91 149.75 - 196.08
20–39	1169	0.00	55.40 49.63 - 61.17	37.81 33.22 - 43.05	10.43 7.45 - 13.41	20.41 16.01 - 24.80	44.07 38.80 - 49.34	73.51 67.82 - 79.20	106.37 96.49 - 116.25	138.78 113.29 - 164.27
40–59	1223	0.00	44.64 41.70 - 47.58	30.52 28.10 - 33.14	8.79 7.04 - 10.55	16.00 12.74 - 19.27	33.63 30.82 - 36.44	60.12 55.97 - 64.27	94.71 83.44 - 105.99	117.92 103.00 - 132.85
60–79	1083	0.00	41.96 39.42 - 44.50	30.35 27.66 - 33.31	9.88 8.35 - 11.40	17.96 15.46 - 20.45	32.31 28.94 - 35.69	54.50 50.92 - 58.08	83.00 74.11 - 91.88	106.63 96.19 - 117.07
Males										
Total, age 6–79	2662	0.00	58.95 55.39 - 62.51	42.20 39.55 - 45.02	12.27 10.01 - 14.52	25.22 22.65 - 27.79	47.47 44.18 - 50.76	76.48 70.93 - 82.03	115.90 104.98 - 126.82	150.42 134.89 - 165.95
6–11	524	0.00	78.74 68.97 - 88.50	58.86 48.68 - 71.17	20.67 13.60 - 27.75	35.68 28.21 - 43.16	64.68 52.15 - 77.22	107.81 92.97 - 122.65	153.12 138.40 - 167.84	184.80 158.80 - 210.80
12–19	505	0.00	76.42 66.40 - 86.43	57.23 50.56 - 64.77	19.67 15.19 - 24.15	38.12 32.42 - 43.82	64.23 56.45 - 72.00	95.93 83.59 - 108.28	132.09 108.53 - 155.65	175.76 133.28 - 218.24
20–39	514	0.00	60.35 55.96 - 64.75	41.91 37.08 - 47.37	11.66 8.37 - 14.95	23.78 18.48 - 29.07	48.48 43.40 - 53.57	78.64 70.86 - 86.43	123.73 110.93 - 136.53	167.99 143.88 - 192.10
40–59	578	0.00	52.58 47.86 - 57.30	38.10 35.25 - 41.18	10.71 8.22 - 13.20	23.00 19.09 - 26.91	41.99 36.48 - 47.50	69.76 61.78 - 77.73	110.41 91.48 - 129.33	135.19 115.18 - 155.19
60–79	541	0.00	47.71 44.68 - 50.74	36.35 33.52 - 39.41	12.97 11.29 - 14.66	23.10 20.19 - 26.01	37.17 32.31 - 42.03	60.90 54.73 - 67.07	92.50 81.28 - 103.71	113.62 100.31 - 126.93
Females										
Total, age 6–79	2830	0.00	47.22 42.63 - 51.81	31.23 27.68 - 35.23	8.60 6.66 - 10.54	16.56 13.70 - 19.42	34.29 30.30 - 38.28	62.85 57.35 - 68.34	98.38 90.73 - 106.03	120.80 108.62 - 132.99
6–11	510	0.00	72.12 61.75 - 82.49	54.03 46.97 - 62.14	17.73 13.37 - 22.10	33.51 27.83 - 39.19	58.38 48.97 - 67.80	100.04 86.17 - 113.91	141.34 113.37 - 169.31	169.78 143.34 - 196.21
12–19	478	0.00	72.02 61.16 - 82.87	50.16 40.41 - 62.27	12.96 7.74 - 18.18	28.13 18.87 - 37.40	58.41 48.27 - 68.56	104.70 89.84 - 119.57	134.54 113.93 - 155.15	168.53 142.69 - 194.37
20–39	655	0.00	50.40 41.31 - 59.49	34.08 28.55 - 40.69	9.47 5.65 - 13.29	18.13 13.45 - 22.81	39.07 31.81 - 46.33	68.87 59.06 - 78.68	95.10 85.85 - 104.35	114.55 93.11 - 135.99
40–59	645	0.00	36.79 33.09 - 40.49	24.50 21.53 - 27.88	6.19 3.99 - 8.38	13.23 10.77 - 15.69	27.63 23.75 - 31.50	51.02 45.37 - 56.66	75.30 65.46 - 85.14	99.08 89.46 - 108.70
60–79	542	0.00	36.68 32.74 - 40.62	25.72 22.03 - 30.03	8.12 5.99 - 10.24	14.67 11.37 - 17.97	27.19 21.80 - 32.58	48.86 45.18 - 52.54	74.11 68.17 - 80.04	91.95 73.98 - 109.92

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.8c

Molybdenum (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95% CI	G.M. 95% CI	10th 95% CI	25th 95% CI	50th 95% CI	75th 95% CI	90th 95% CI	95th 95% CI
Total, age 6–79	5479	0.00	53.67 50.70 - 56.64	43.89 41.89 - 45.98	20.59 19.17 - 22.02	29.78 28.11 - 31.44	43.20 41.82 - 44.58	64.11 61.15 - 67.07	95.98 88.68 - 103.28	121.58 112.49 - 130.67
6–11	1031	0.00	100.32 95.10 - 105.53	87.00 83.51 - 90.64	46.89 43.45 - 50.33	62.77 60.39 - 65.16	84.59 79.41 - 89.78	121.86 114.29 - 129.42	173.32 153.07 - 193.57	217.99 194.33 - 241.64
12–19	982	0.00	56.26 50.26 - 62.26	46.79 42.90 - 51.02	22.12 19.46 - 24.77	32.06 27.99 - 36.13	46.80 42.66 - 50.94	69.75 63.23 - 76.28	96.88 84.01 - 109.75	114.07 101.92 - 126.21
20–39	1165	0.00	50.78 46.37 - 55.19	42.19 39.72 - 44.82	20.19 17.97 - 22.41	29.80 27.12 - 32.47	42.44 39.50 - 45.37	59.30 54.88 - 63.72	87.36 75.86 - 98.85	112.16 94.91 - 129.41
40–59	1218	0.00	46.60 43.64 - 49.56	39.08 36.41 - 41.95	19.84 16.93 - 22.75	26.46 23.38 - 29.54	39.11 36.67 - 41.55	54.79 50.00 - 59.57	82.17 77.49 - 86.85	107.33 95.57 - 119.09
60–79	1083	0.00	51.29 48.45 - 54.13	42.45 39.34 - 45.80	19.44 16.52 - 22.35	29.42 26.26 - 32.57	43.04 40.08 - 46.00	61.46 56.41 - 66.52	88.48 82.12 - 94.83	111.51 99.70 - 123.32
Males										
Total, age 6–79	2653	0.00	51.03 47.84 - 54.22	41.65 39.95 - 43.42	19.86 18.44 - 21.27	27.31 25.41 - 29.21	40.58 38.97 - 42.19	61.18 56.89 - 65.46	90.81 81.68 - 99.94	117.53 107.02 - 128.04
6–11	522	0.00	103.21 95.67 - 110.76	89.36 83.55 - 95.57	48.06 41.28 - 54.85	64.94 61.14 - 68.73	87.52 80.72 - 94.32	123.72 114.99 - 132.45	182.14 153.41 - 210.86	226.52 200.83 - 252.22
12–19	504	0.00	58.68 50.73 - 66.64	48.24 43.67 - 53.28	23.04 20.73 - 25.34	32.45 27.62 - 37.28	48.82 44.47 - 53.16	72.32 65.29 - 79.35	100.50 85.68 - 115.32	114.51 92.78 - 136.24
20–39	512	0.00	45.55 41.27 - 49.83	38.40 35.81 - 41.19	18.09 16.43 - 19.75	25.70 21.66 - 29.73	38.93 35.46 - 42.41	57.16 50.93 - 63.39	80.77 67.16 - 94.39	97.49 73.78 - 121.20
40–59	574	0.00	44.49 40.80 - 48.17	37.46 35.04 - 40.05	20.02 17.62 - 22.41	25.20 23.36 - 27.04	36.65 34.80 - 38.50	51.37 47.08 - 55.66	80.77 70.93 - 90.61	105.08 84.70 - 125.46
60–79	541	0.00	45.54 42.11 - 48.97	38.33 34.63 - 42.43	18.22 14.99 - 21.45	26.45 22.84 - 30.06	38.26 34.40 - 42.11	56.04 50.22 - 61.85	77.76 69.61 - 85.90	97.54 85.34 - 109.74
Females										
Total, age 6–79	2826	0.00	56.30 52.87 - 59.73	46.24 43.55 - 49.09	21.52 19.08 - 23.97	31.94 29.97 - 33.92	45.93 43.37 - 48.48	66.36 62.54 - 70.18	100.92 91.68 - 110.15	127.94 115.75 - 140.14
6–11	509	0.00	97.26 88.59 - 105.94	84.59 79.00 - 90.58	46.66 42.27 - 51.05	59.66 54.87 - 64.45	81.40 75.34 - 87.45	118.18 104.37 - 131.99	164.77 140.07 - 189.46	196.53 153.78 - 239.28
12–19	478	0.00	53.61 47.53 - 59.70	45.25 40.57 - 50.47	20.68 17.49 - 23.86	31.01 25.84 - 36.17	44.33 38.28 - 50.38	67.03 58.31 - 75.75	90.61 71.25 - 109.97	113.55 101.51 - 125.60
20–39	653	0.00	56.05 48.98 - 63.12	46.39 42.34 - 50.83	24.40 22.62 - 26.19	31.92 30.22 - 33.62	45.73 41.37 - 50.10	62.24 54.57 - 69.92	96.75 79.36 - 114.14	127.61 80.82 - 174.40
40–59	644	0.00	48.68 44.59 - 52.77	40.75 37.01 - 44.86	19.08 14.70 - 23.46	28.53 23.32 - 33.73	41.39 38.12 - 44.66	60.17 54.55 - 65.79	86.43 74.36 - 98.50	107.84 93.47 - 122.21
60–79	542	0.00	56.57 53.25 - 59.88	46.62 42.93 - 50.62	20.61 16.01 - 25.21	32.70 27.92 - 37.47	48.32 42.30 - 54.34	68.63 60.30 - 76.95	94.57 83.63 - 105.51	125.21 111.61 - 138.81

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.1.9 Nickel (CASRN 7440-02-0)

Nickel (Ni) is a naturally occurring metal found in many types of rock. It is the 24th most abundant element in the Earth's crust and in its pure form is hard and silvery-white. However, nickel occurs most frequently in combination with sulphur, arsenic, and antimony. Nickel is a very reactive heavy metal that forms various divalent compounds, including nickel sulphate, nickel oxide, nickel sulphide, nickel subsulphide, and nickel carbonate. Canada was ranked as the second largest producer of nickel in the world in 1990, with Ontario (Sudbury) and Manitoba (Thompson) producing 65% and 35%, respectively, of the Canadian nickel (Environment Canada & Health Canada, 1994).

Due to its unique physical properties, nickel is commonly combined with other metals, including iron, copper, chromium, and zinc to form alloys. Nickel alloys are used in metal coins, jewellery, and heat exchangers. Nickel compounds are used in nickel plating, batteries, ceramic colouring, and as catalysts to increase rates of chemical reactions. Nickel is also a component of stainless steel, which has widespread application in a variety of home, medical, and industrial settings (ATSDR, 2005; CCME, 1996).

Nickel is released into the environment as a result of natural processes, including weathering of geological deposits, and also as a result of human activities, including mining, smelting, refining and other metal operations, fuel combustion, electric power generation and waste incineration (Environment Canada & Health Canada, 1994).

Given its natural abundance in the environment, everyone is exposed to small amounts of nickel. The main source of exposure for the general population is food. Other sources of nickel exposure include air, drinking water, soil, and household dust. Nickel exposure can also occur through dermal contact with alloys containing nickel (e.g., jewellery), and through dermal contact with nickel-containing products, such as cosmetics (generally present as an impurity); household cleaning and bleaching agents; and, medical products, such as joint implants, intrauterine devices, and acupuncture needles (ATSDR, 2005; Basketter et al., 2003). Nickel exposure can also occur from inhalation of cigarette smoke (ATSDR, 2005).

Nickel and nickel compounds are absorbed from the respiratory tract and to a lesser extent, from the gastrointestinal tract and skin. Approximately 20–35% of inhaled nickel is absorbed into the blood from the respiratory tract following inhalation (ATSDR, 2005), while only 1–10% of ingested nickel is absorbed, depending largely on the composition of the diet (WHO, 1991). Nickel has been measured in a variety of organs, including the lungs, thyroid, adrenals, kidneys, heart, liver, brain, spleen, and pancreas (ATSDR, 2005). Nickel is excreted in urine and feces, and has an estimated elimination half-life of 17 to 48 hours (Nieboer & Fletcher, 2001). Nickel can be measured in urine, serum, whole blood, feces, hair, sweat, and breast milk; urine is the most commonly used matrix for biological monitoring of nickel (Sunderman, 1993).

Studies indicate that nickel is an essential element in a number of laboratory animal species, and it has been postulated to be an essential element in humans (Environment Canada & Health Canada, 1994). Although there may be benefits from small doses of nickel, exposure to high levels may result in adverse health effects. These effects are dependent on the route of exposure and, in the case of inhalation, the species of nickel. Allergy to nickel is common and can cause severe contact dermatitis. The condition can be painful, but is not life threatening and can be managed by avoiding extended contact between the skin and nickel-containing jewellery, buttons, belt buckles, and similar items (ATSDR, 2005).

Health Canada and Environment Canada assessed nickel and its various compounds and concluded that metallic nickel was not a concern for human health at current levels of exposure (Environment Canada and Health Canada, 1994). However, the "oxidic" (including nickel oxide, nickel-copper oxide, nickel-silicate oxides, and complex oxides), "sulphidic" (including nickel subsulphide), and "soluble" (primarily nickel sulphate and nickel chloride) nickel groups, as a whole, are entering the environment in a quantity or concentration or under conditions that may constitute a danger in Canada to human life or health.

Health Canada has classified metallic nickel as VI: unclassifiable with respect to carcinogenicity in humans (Health Canada, 1996). However, oxidic, sulphidic, and soluble nickel are classified as a human carcinogen (Group I) for inhalation exposure (Health Canada, 1996). Health Canada (2005) has adopted Tolerable Upper Intake Levels (UL) developed by the Institute of Medicine (IOM) for nickel (IOM, 2001). The UL for nickel is 0.2 to 0.6 mg/day for children aged 1–13, and 1.0 mg/day for those over the age of 14 (Health Canada, 2005).

In a study carried out in 2001 in the Québec City region, in 500 participants aged 18–65, the geometric mean and 90th percentile values of nickel in blood were <0.59 µg/L and 0.85 µg/L, respectively. The geometric mean and 90th percentile values of nickel in urine were 1.78 µg/L and 4.46 µg/L, respectively (INSPQ, 2004).

Nickel was measured in the blood and urine of all participants aged 6–79 years in the Canadian Health Measures Survey and is presented as µg/L blood and both µg/L and µg/g creatinine in urine (Tables 8.1.9a, 8.1.9b, 8.1.9c). Finding a measurable amount of nickel in blood or urine is an indicator of exposure to nickel and does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for blood and urinary levels of nickel in the Canadian population.

Table 8.1.9a

Nickel – Arithmetic and geometric means, and selected percentiles of blood concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5319	6.69	0.75 0.65 - 0.84	0.62 0.55 - 0.68	<LOD <LOD - 0.45	0.47 0.40 - 0.53	0.58 0.53 - 0.63	0.59 <LOD - 1.03	1.23 1.00 - 1.46	1.70 1.32 - 2.08
6–11	910	6.37	0.86 0.72 - 1.01	0.67 0.59 - 0.76	<LOD <LOD - 0.42	0.47 0.43 - 0.52	0.55 0.54 - 0.56	1.06 0.45 - 1.66	1.52 1.17 - 1.87	2.13 1.53 - 2.74
12–19	945	7.20	0.78 0.65 - 0.92	0.63 0.55 - 0.72	<LOD <LOD - 0.42	0.45 0.40 - 0.50	0.55 0.54 - 0.56	0.92 0.38 - 1.45	1.40 1.01 - 1.79	1.78 1.41 - 2.15
20–39	1165	6.95	0.72 0.65 - 0.79	0.61 0.56 - 0.66	<LOD <LOD - 0.44	0.50 0.43 - 0.57	0.56 0.54 - 0.59	0.58 <LOD - 0.83	1.18 0.99 - 1.37	1.58 1.15 - 2.02
40–59	1220	6.80	0.72 0.61 - 0.83	0.60 0.53 - 0.69	<LOD <LOD - 0.46	0.46 0.38 - 0.54	0.58 0.52 - 0.63	0.59 <LOD - 0.94	1.19 0.94 - 1.43	1.64 1.22 - 2.06
60–79	1079	6.12	0.78 0.67 - 0.89	0.63 0.57 - 0.70	<LOD <LOD - 0.43	0.47 0.41 - 0.52	0.57 0.54 - 0.60	0.92 0.37 - 1.48	1.22 1.04 - 1.40	1.64 1.10 - 2.18
Males										
Total, age 6–79	2576	6.72	0.72 0.63 - 0.81	0.60 0.54 - 0.67	<LOD <LOD - 0.45	0.47 0.42 - 0.51	0.55 0.53 - 0.56	0.58 <LOD - 0.95	1.19 1.00 - 1.39	1.52 1.19 - 1.86
6–11	459	8.06	0.87 0.71 - 1.02	0.66 0.58 - 0.74	<LOD <LOD - 0.36	0.46 0.40 - 0.52	0.55 0.54 - 0.56	1.03 0.39 - 1.68	1.53 1.20 - 1.85	2.26 1.59 - 2.94
12–19	489	7.98	0.77 0.65 - 0.90	0.62 0.55 - 0.70	<LOD <LOD - 0.38	0.45 0.41 - 0.48	0.55 0.54 - 0.56	1.00 0.44 - 1.57	1.41 1.06 - 1.76	1.77 1.40 - 2.13
20–39	514	5.84	0.67 0.58 - 0.77	0.59 0.53 - 0.65	<LOD <LOD - 0.46	0.47 0.43 - 0.51	0.55 0.53 - 0.56	0.58 0.45 - 0.71	1.16 1.06 - 1.26	1.32 1.15 - 1.48
40–59	577	6.93	0.69 0.59 - 0.79	0.59 0.51 - 0.68	0.36 <LOD - 0.49	0.46 0.40 - 0.52	0.54 0.53 - 0.56	0.58 <LOD - 0.97	1.17 0.92 - 1.43	1.46 1.05 - 1.88
60–79	537	5.03	0.77 0.68 - 0.87	0.63 0.57 - 0.69	<LOD <LOD - 0.43	0.46 0.41 - 0.52	0.55 0.54 - 0.57	0.89 0.37 - 1.41	1.27 1.05 - 1.49	1.73 1.15 - 2.30
Females										
Total, age 6–79	2743	6.67	0.77 0.67 - 0.88	0.63 0.56 - 0.70	<LOD <LOD - 0.45	0.46 0.39 - 0.53	0.58 0.53 - 0.63	0.59 <LOD - 1.11	1.29 0.98 - 1.60	1.83 1.42 - 2.25
6–11	451	4.66	0.86 0.69 - 1.04	0.68 0.59 - 0.78	0.37 <LOD - 0.46	0.48 0.44 - 0.53	0.55 0.54 - 0.57	1.09 0.59 - 1.59	1.43 1.04 - 1.82	1.91 1.19 - 2.63
12–19	456	6.36	0.80 0.63 - 0.96	0.63 0.53 - 0.75	<LOD <LOD - 0.46	0.45 0.38 - 0.51	0.55 0.54 - 0.56	0.59 <LOD - 1.34	1.39 0.92 - 1.86	1.80 1.26 - 2.35
20–39	651	7.83	0.77 0.69 - 0.85	0.63 0.57 - 0.69	<LOD <LOD - 0.43	0.47 0.41 - 0.53	0.57 0.54 - 0.59	0.59 <LOD - 1.10	1.34 0.89 - 1.79	1.96 1.53 - 2.39
40–59	643	6.69	0.75 0.62 - 0.88	0.61 0.53 - 0.70	<LOD <LOD - 0.45	0.44 0.37 - 0.52	0.58 0.52 - 0.63	0.59 <LOD - 0.94	1.24 0.98 - 1.51	1.79 1.33 - 2.24
60–79	542	7.20	0.78 0.64 - 0.93	0.63 0.55 - 0.72	<LOD <LOD - 0.42	0.47 0.40 - 0.54	0.57 0.54 - 0.60	0.95 0.36 - 1.54	1.17 0.99 - 1.35	1.59 1.04 - 2.14

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.9b

Nickel – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5491	3.15	1.62 1.53 - 1.71	1.10 1.04 - 1.18	0.35 0.31 - 0.38	0.65 0.61 - 0.69	1.16 1.09 - 1.23	2.03 1.90 - 2.16	3.28 3.01 - 3.55	4.47 4.08 - 4.85
6–11	1034	2.80	1.91 1.64 - 2.17	1.30 1.10 - 1.55	0.38 0.24 - 0.52	0.79 0.68 - 0.90	1.43 1.21 - 1.66	2.54 2.18 - 2.90	3.79 3.32 - 4.26	5.03 4.26 - 5.81
12–19	983	1.73	2.12 1.91 - 2.34	1.52 1.38 - 1.69	0.49 0.38 - 0.59	0.99 0.88 - 1.10	1.61 1.53 - 1.69	2.59 2.32 - 2.85	4.20 3.62 - 4.79	5.33 4.22 - 6.45
20–39	1168	3.68	1.43 1.28 - 1.58	1.00 0.89 - 1.13	0.32 0.27 - 0.37	0.63 0.56 - 0.70	1.06 0.95 - 1.16	1.76 1.53 - 2.00	2.79 2.37 - 3.21	3.71 3.15 - 4.28
40–59	1223	5.07	1.56 1.46 - 1.66	1.03 0.96 - 1.12	0.33 0.29 - 0.37	0.59 0.53 - 0.65	1.06 0.95 - 1.17	2.02 1.87 - 2.17	3.20 2.84 - 3.55	4.63 3.34 - 5.91
60–79	1083	2.03	1.64 1.49 - 1.78	1.13 1.06 - 1.21	0.40 0.35 - 0.46	0.65 0.59 - 0.72	1.13 1.07 - 1.19	1.95 1.80 - 2.11	3.27 2.66 - 3.88	4.68 3.82 - 5.53
Males										
Total, age 6–79	2662	2.85	1.66 1.55 - 1.77	1.15 1.09 - 1.21	0.38 0.35 - 0.42	0.71 0.66 - 0.76	1.19 1.13 - 1.26	2.04 1.89 - 2.19	3.46 3.06 - 3.87	4.57 3.80 - 5.33
6–11	524	3.05	1.88 1.56 - 2.20	1.30 1.01 - 1.67	0.36 <LOD - 0.57	0.87 0.65 - 1.08	1.49 1.16 - 1.82	2.63 2.15 - 3.11	3.66 3.10 - 4.23	4.63 4.03 - 5.22
12–19	505	1.19	1.93 1.68 - 2.19	1.43 1.27 - 1.60	0.47 0.37 - 0.57	0.98 0.85 - 1.11	1.49 1.32 - 1.66	2.26 2.01 - 2.52	3.80 2.86 - 4.74	4.81 3.14 - 6.48
20–39	514	3.89	1.43 1.21 - 1.64	1.01 0.90 - 1.12	0.33 0.23 - 0.43	0.68 0.59 - 0.78	1.08 1.00 - 1.16	1.62 1.31 - 1.93	2.82 2.05 - 3.59	3.77 3.02 - 4.51
40–59	578	4.33	1.66 1.46 - 1.86	1.12 0.99 - 1.26	0.38 0.30 - 0.47	0.63 0.52 - 0.74	1.13 0.93 - 1.32	2.06 1.74 - 2.38	3.54 2.99 - 4.09	5.44 4.51 - 6.37
60–79	541	1.66	1.78 1.52 - 2.05	1.25 1.14 - 1.38	0.47 0.43 - 0.51	0.72 0.65 - 0.80	1.27 1.12 - 1.41	2.14 1.76 - 2.52	3.73 2.69 - 4.76	5.54 3.56 - 7.52
Females										
Total, age 6–79	2829	3.43	1.58 1.47 - 1.70	1.06 0.97 - 1.17	0.33 0.28 - 0.37	0.60 0.52 - 0.67	1.11 0.98 - 1.24	2.03 1.88 - 2.18	3.15 2.93 - 3.37	4.37 3.71 - 5.03
6–11	510	2.55	1.94 1.68 - 2.19	1.31 1.16 - 1.48	0.43 0.30 - 0.57	0.78 0.70 - 0.85	1.35 1.14 - 1.57	2.36 1.98 - 2.74	3.95 3.37 - 4.53	5.44 4.48 - 6.40
12–19	478	2.30	2.33 2.06 - 2.60	1.64 1.40 - 1.93	0.49 0.23 - 0.75	0.99 0.81 - 1.17	1.85 1.63 - 2.07	3.02 2.67 - 3.38	4.42 3.55 - 5.29	5.75 4.00 - 7.50
20–39	654	3.52	1.43 1.22 - 1.64	1.00 0.82 - 1.20	0.31 0.21 - 0.41	0.59 0.50 - 0.69	1.05 0.85 - 1.26	1.82 1.42 - 2.21	2.78 2.38 - 3.18	3.36 2.25 - 4.47
40–59	645	5.74	1.46 1.30 - 1.62	0.96 0.85 - 1.08	0.31 0.23 - 0.39	0.51 0.41 - 0.60	1.03 0.87 - 1.20	1.94 1.75 - 2.13	3.01 2.63 - 3.38	3.79 2.08 - 5.51
60–79	542	2.40	1.50 1.35 - 1.64	1.03 0.92 - 1.14	0.34 0.25 - 0.43	0.59 0.50 - 0.67	1.03 0.89 - 1.17	1.77 1.57 - 1.96	3.02 2.46 - 3.58	4.30 3.35 - 5.25

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.9c

Nickel (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5478	3.16	1.77 1.66 - 1.89	1.34 1.27 - 1.41	0.56 0.53 - 0.58	0.83 0.78 - 0.88	1.32 1.26 - 1.39	2.08 1.97 - 2.19	3.27 2.95 - 3.60	4.51 3.97 - 5.04
6–11	1031	2.81	2.59 2.25 - 2.93	2.00 1.78 - 2.26	0.86 0.70 - 1.02	1.34 1.24 - 1.44	2.02 1.79 - 2.25	3.02 2.70 - 3.34	4.46 3.86 - 5.06	5.69 4.61 - 6.76
12–19	982	1.73	1.72 1.55 - 1.90	1.33 1.23 - 1.44	0.58 0.52 - 0.63	0.84 0.79 - 0.88	1.32 1.19 - 1.46	2.04 1.74 - 2.34	3.27 2.67 - 3.86	4.00 3.67 - 4.34
20–39	1164	3.69	1.45 1.30 - 1.60	1.12 1.02 - 1.23	0.47 0.42 - 0.52	0.72 0.66 - 0.78	1.13 1.01 - 1.26	1.69 1.53 - 1.85	2.61 2.22 - 3.00	3.91 2.92 - 4.89
40–59	1218	5.09	1.75 1.61 - 1.89	1.33 1.26 - 1.40	0.57 0.53 - 0.62	0.83 0.75 - 0.91	1.31 1.22 - 1.41	2.06 1.97 - 2.15	3.19 2.85 - 3.54	4.46 3.52 - 5.40
60–79	1083	2.03	2.10 1.92 - 2.29	1.58 1.50 - 1.66	0.67 0.59 - 0.76	0.98 0.90 - 1.06	1.57 1.48 - 1.67	2.43 2.29 - 2.58	3.88 3.42 - 4.34	5.27 4.76 - 5.79
Males										
Total, age 6–79	2653	2.86	1.50 1.37 - 1.63	1.13 1.06 - 1.20	0.49 0.45 - 0.52	0.70 0.66 - 0.74	1.09 1.03 - 1.15	1.75 1.61 - 1.88	2.79 2.51 - 3.07	3.78 3.22 - 4.34
6–11	522	3.07	2.54 2.14 - 2.93	1.96 1.72 - 2.24	0.83 <LOD - 1.03	1.33 1.13 - 1.53	2.06 1.72 - 2.40	2.90 2.59 - 3.21	4.30 3.90 - 4.71	5.25 3.51 - 6.99
12–19	504	1.19	1.54 1.42 - 1.67	1.20 1.11 - 1.29	0.55 0.47 - 0.63	0.74 0.65 - 0.84	1.08 0.94 - 1.21	1.83 1.59 - 2.07	3.00 2.32 - 3.68	4.14 3.39 - 4.88
20–39	512	3.91	1.16 0.97 - 1.36	0.92 0.81 - 1.06	0.40 0.35 - 0.45	0.59 0.50 - 0.68	0.90 0.77 - 1.03	1.40 1.12 - 1.67	2.02 1.58 - 2.47	2.78 1.98 - 3.58
40–59	574	4.36	1.47 1.26 - 1.67	1.10 1.01 - 1.20	0.50 0.44 - 0.57	0.68 0.61 - 0.74	1.07 0.98 - 1.17	1.65 1.43 - 1.87	2.59 2.17 - 3.00	3.48 2.62 - 4.34
60–79	541	1.66	1.71 1.48 - 1.94	1.32 1.21 - 1.45	0.57 0.49 - 0.64	0.86 0.80 - 0.92	1.24 1.12 - 1.37	2.02 1.75 - 2.29	3.20 2.60 - 3.81	4.82 3.20 - 6.43
Females										
Total, age 6–79	2825	3.43	2.05 1.86 - 2.23	1.58 1.47 - 1.69	0.70 0.64 - 0.76	1.02 0.93 - 1.11	1.53 1.44 - 1.62	2.33 2.12 - 2.54	3.82 3.27 - 4.37	5.16 4.25 - 6.06
6–11	509	2.55	2.65 2.27 - 3.02	2.05 1.82 - 2.31	0.93 0.76 - 1.11	1.34 1.25 - 1.42	1.97 1.78 - 2.16	3.18 2.70 - 3.66	4.81 4.00 - 5.62	5.72 4.50 - 6.94
12–19	478	2.30	1.92 1.65 - 2.19	1.48 1.31 - 1.68	0.64 0.47 - 0.80	0.95 0.81 - 1.10	1.53 1.35 - 1.71	2.23 1.82 - 2.64	3.34 2.77 - 3.92	3.92 3.30 - 4.54
20–39	652	3.53	1.74 1.51 - 1.97	1.36 1.18 - 1.57	0.63 0.52 - 0.74	0.89 0.74 - 1.03	1.31 1.12 - 1.49	2.03 1.81 - 2.25	3.29 2.22 - 4.36	4.59 3.68 - 5.50
40–59	644	5.75	2.02 1.82 - 2.23	1.60 1.48 - 1.72	0.73 0.65 - 0.81	1.06 0.91 - 1.20	1.56 1.42 - 1.69	2.27 1.98 - 2.57	3.69 2.95 - 4.43	4.96 3.63 - 6.30
60–79	542	2.40	2.46 2.09 - 2.84	1.86 1.71 - 2.02	0.81 0.66 - 0.96	1.17 0.99 - 1.34	1.89 1.76 - 2.02	2.70 2.36 - 3.03	4.25 3.47 - 5.03	5.89 4.78 - 7.01

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.1.10 Selenium (CASRN 7782-49-2)

Selenium (Se) is a naturally occurring essential element that comprises a small fraction of the Earth's crust. It is a metalloid and cannot be broken down, but can be transformed by sunlight, water, and air to various oxidation states and forms. Selenium is present in the environment in inorganic form as selenide (Se^{2-}), selenate (SeO_4^{2-}), and selenite (SeO_3^{2-}). It is widely distributed in the Earth's crust at concentrations averaging 0.09 mg/kg and is found in trace quantities in most plant and animal tissues (Schamberger, 1984). Selenium is an essential nutrient required for the maintenance of good health (ATSDR, 2003).

Elevated levels of selenium in the environment may occur naturally from weathering of heavy metal deposits and soils (CCME, 2007), or as the result of anthropogenic activities such as mining or metallurgical processes. Selenium is produced mainly as a by-product of copper refining and also from recycling of metal products. Other sources of selenium emissions include incinerator stacks, burning coal or oil, and any large-scale combustion processes due to the widespread distribution of selenium in nature.

Canada is one of the largest selenium producers and exporters globally. Historically, the primary use of selenium was in the electronics industry in the form of arsenic triselenide, used as a photoreceptor for photocopiers. However, arsenic triselenide has generally been replaced by more environmentally friendly compounds in recent years. As selenium has various electrical and conductive properties, it is also used in light meters, photoelectric and solar cells, semi-conductors, and arc light electrodes. It is also used as a colourizing and decolourizing agent for glass and to reduce solar heat for architectural glass. It can be used to develop red, orange, and maroon pigments for ceramics, glazes, plastics, enamels, and paints, but this practice is generally restricted due to the potential for selenium toxicity. Selenium is also present in stainless steel, enamels, inks, rubber, pesticides, fungicides, batteries, explosives, and shampoos. Products containing selenium are generally considered non-toxic when used as directed, but the selenium may be released upon disposal if incinerated (CCME, 2007; ATSDR, 2003).

The Canadian population is exposed to selenium compounds in ambient air, drinking water, soil, and food. It is estimated that more than 98% of the total daily intake of selenium occurs through food consumption (IOM, 2000). Exposure to selenium may also occur from the use of therapeutic products, including shampoos used to treat dandruff and seborrheic dermatitis, and certain antifungal skin lotions. A Canadian study reported that adults consume an average of 113–220 µg selenium per day (Thompson et al., 1975).

Absorption of selenium is dependent on the chemical form, with organic forms (e.g., selenoamino acids such as selenomethionine and selenocysteine) absorbed more readily than inorganic forms, as well as on the overall exposure level, with absorption increasing when selenium levels in the body are low (IOM, 2000). Following ingestion, selenium is readily absorbed in the gastrointestinal tract. Selenium can also be absorbed through the lungs, with acidic forms absorbing more readily (CCME, 2007). Once inside the body, selenium generally concentrates in the liver and kidneys, regardless of the initial chemical form. Selenium can also be found in significant amounts in nails and hair (IOM, 2000). Approximately 50–80% of absorbed selenium is eliminated in the urine (Marier & Jaworski, 1983).

Selenium is an essential nutrient and a component of several proteins and enzymes in the body. Selenium aids in the defence of oxidative stress, the regulation of thyroid hormone action, and the regulation of the redox status of Vitamin C and other molecules (IOM, 2000). The Recommended Dietary Allowance (RDA) for Canadians is 15 µg/day for young infants, 20–30 µg/day for children up to age 12, and 55 µg/day for adolescents and adults (Health Canada, 2005).

As is generally the case with essential trace elements, selenium can have detrimental health effects when ingested at levels much greater than the recommended daily intake. The level at which selenium toxicity occurs is difficult to determine, as it is affected by the types of protein in the diet, levels of vitamin E, and the various forms of selenium present in the body (Health Canada, 1992). The symptoms of selenium deficiency and excess are similar. Oral intake of large amounts of selenium can result in nausea, vomiting, and diarrhea.

Chronic levels of high selenium can cause selenosis, a disease that results in hair loss, nail brittleness, and neurological abnormalities (IOM, 2000; ATSDR, 2003; WHO, 2003). There is no evidence in humans of reproductive effects or developmental abnormalities; the International Agency for Research on Cancer (IARC) has determined that selenium is not classifiable as to its carcinogenicity to humans (Group 3) (IARC, 1987).

Health Canada (2005) has adopted Tolerable Upper Intake Levels (UL) developed by the Institute of Medicine (IOM) for selenium, which account for both its essentiality and its potential toxicity. The ULs for selenium are 45 µg/day for infants 0–6 months old, 60 µg/day for infants 7–12 months old, 90 µg/day for children 1–3 years old, 150 µg/day for children 4–8 years old, 280 µg/day for children 9–13 years old, and 400 µg/day for adolescents 14–18 years old and adults (IOM, 2000). A maximum acceptable concentration of 0.01 mg/L (10 µg/L) for selenium in drinking water has been established on the basis of health considerations and is currently under revision (Health Canada, 1992).

Selenium levels in the body following both short- and long-term exposure can be determined through blood and urine tests (IOM, 2000).

In a study carried out in the region of Québec City on adults aged 18–65, the geometric mean and 90th percentile values of selenium in urine were 63.19 µg/L and 132.65 µg/L, respectively. The geometric mean and 90th percentile values of selenium in blood were 221.17 µg/L and 261.45 µg/L, respectively (INSPQ, 2004).

Selenium was measured in the blood and urine of all participants aged 6–79 years in the Canadian Health Measures Survey and is presented as µg/L in blood and as both µg/L and µg/g creatinine in urine (Tables 8.1.10a, 8.1.10b, 8.1.10c). Finding a measurable amount of selenium in blood or urine is an indicator of exposure to selenium and does not necessarily mean that an adverse health effect will occur. Since it is an essential nutrient, its presence is expected. These data provide reference ranges for blood and urinary levels of selenium in the Canadian population.

Table 8.1.10a

Selenium – Arithmetic and geometric means, and selected percentiles of blood concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95% CI	G.M. 95% CI	10th 95% CI	25th 95% CI	50th 95% CI	75th 95% CI	90th 95% CI	95th 95% CI
Total, age 6–79	5319	0.00	204.01 199.73 - 208.28	201.56 197.55 - 205.66	168.90 164.62 - 173.17	182.76 178.57 - 186.95	199.70 196.22 - 203.18	219.49 214.75 - 224.22	241.39 235.53 - 247.25	253.25 245.31 - 261.20
6–11	910	0.00	188.36 185.29 - 191.43	186.86 183.89 - 189.88	159.81 155.73 - 163.89	171.59 167.91 - 175.26	185.43 182.48 - 188.37	201.13 199.19 - 203.07	217.45 213.48 - 221.42	231.76 222.47 - 241.04
12–19	945	0.00	198.29 193.77 - 202.82	196.17 191.65 - 200.80	165.45 160.50 - 170.39	178.05 173.52 - 182.58	194.52 191.24 - 197.79	212.46 206.15 - 218.76	238.47 230.64 - 246.30	251.07 237.22 - 264.93
20–39	1165	0.00	205.62 200.17 - 211.08	202.73 198.42 - 207.13	169.82 165.96 - 173.68	185.37 180.41 - 190.34	199.88 195.85 - 203.92	219.55 214.53 - 224.56	242.30 233.49 - 251.12	252.76 238.95 - 266.56
40–59	1220	0.00	206.15 201.63 - 210.67	203.94 199.51 - 208.47	171.43 166.14 - 176.73	184.34 179.46 - 189.22	202.81 198.23 - 207.39	223.74 217.63 - 229.84	243.59 236.47 - 250.71	255.01 245.42 - 264.61
60–79	1079	0.00	206.35 199.87 - 212.83	204.01 197.92 - 210.28	172.11 167.59 - 176.62	186.16 180.99 - 191.32	201.16 194.89 - 207.42	223.22 215.79 - 230.66	243.95 234.54 - 253.36	256.45 241.97 - 270.94
Males										
Total, age 6–79	2576	0.00	207.46 202.25 - 212.66	204.84 200.32 - 209.45	172.01 167.37 - 176.64	185.41 181.36 - 189.45	202.09 197.83 - 206.34	224.24 218.37 - 230.12	244.68 237.87 - 251.49	256.31 242.62 - 270.00
6–11	459	0.00	187.32 183.88 - 190.77	186.03 182.68 - 189.44	159.99 155.79 - 164.18	171.65 167.65 - 175.65	183.71 179.68 - 187.74	199.62 194.18 - 205.07	215.75 208.14 - 223.37	233.39 216.30 - 250.49
12–19	489	0.00	198.92 194.29 - 203.56	196.87 192.51 - 201.34	166.95 161.98 - 171.92	178.30 174.82 - 181.78	193.52 189.87 - 197.17	215.32 205.45 - 225.20	237.80 227.49 - 248.12	247.67 229.27 - 266.07
20–39	514	0.00	211.71 202.23 - 221.19	207.95 201.69 - 214.41	175.02 169.14 - 180.91	187.21 182.46 - 191.95	203.51 198.65 - 208.37	224.99 217.28 - 232.70	246.43 235.51 - 257.35	266.01 237.57 - 294.45
40–59	577	0.00	210.32 203.29 - 217.36	208.36 201.47 - 215.48	175.32 166.56 - 184.09	189.53 182.14 - 196.92	207.07 199.39 - 214.76	226.78 219.44 - 234.13	246.89 239.04 - 254.75	255.86 240.07 - 271.64
60–79	537	0.00	207.40 200.42 - 214.38	205.27 198.35 - 212.43	174.96 168.44 - 181.48	187.90 182.62 - 193.18	205.05 197.56 - 212.55	224.09 214.32 - 233.85	243.64 232.82 - 254.46	255.99 243.77 - 268.20
Females										
Total, age 6–79	2743	0.00	200.53 196.28 - 204.79	198.32 194.28 - 202.45	166.53 162.29 - 170.78	180.67 175.58 - 185.76	197.34 193.69 - 200.99	215.51 211.36 - 219.66	235.99 230.76 - 241.22	249.47 241.16 - 257.78
6–11	451	0.00	189.45 185.98 - 192.92	187.75 184.32 - 191.24	159.03 153.39 - 164.68	171.49 165.94 - 177.03	186.62 183.31 - 189.93	201.60 196.86 - 206.33	218.77 211.98 - 225.56	230.09 221.68 - 238.51
12–19	456	0.00	197.61 192.04 - 203.17	195.40 189.70 - 201.26	164.27 157.26 - 171.27	177.57 170.56 - 184.57	194.77 190.00 - 199.55	210.56 202.76 - 218.35	240.05 230.43 - 249.67	253.92 244.38 - 263.46
20–39	651	0.00	199.33 194.25 - 204.41	197.46 192.54 - 202.50	167.18 161.28 - 173.07	180.94 171.36 - 190.51	195.97 191.45 - 200.48	216.29 209.69 - 222.89	233.68 225.47 - 241.89	247.44 239.35 - 255.52
40–59	643	0.00	202.00 197.78 - 206.23	199.65 195.76 - 203.62	166.68 161.64 - 171.73	180.77 177.71 - 183.83	198.26 193.63 - 202.90	215.48 208.99 - 221.98	235.33 228.01 - 242.65	253.23 239.88 - 266.58
60–79	542	0.00	205.39 197.37 - 213.41	202.86 195.76 - 210.22	170.54 165.69 - 175.38	183.14 176.69 - 189.58	198.88 193.12 - 204.65	222.65 213.37 - 231.92	244.02 231.53 - 256.52	259.30 238.22 - 280.37

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.10b

Selenium – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5492	0.46	63.05 58.25 - 67.86	48.86 44.72 - 53.38	16.97 14.41 - 19.53	30.46 26.75 - 34.17	53.68 48.68 - 58.69	85.52 79.54 - 91.50	121.07 111.68 - 130.45	143.65 136.37 - 150.93
6–11	1034	0.48	74.79 68.52 - 81.05	60.20 53.89 - 67.24	22.41 18.81 - 26.02	40.23 33.41 - 47.05	67.55 60.85 - 74.25	102.57 91.61 - 113.54	129.49 118.79 - 140.19	153.69 144.13 - 163.25
12–19	983	0.00	78.02 70.10 - 85.93	62.62 54.89 - 71.42	22.20 16.22 - 28.18	42.53 32.87 - 52.18	70.74 62.95 - 78.53	103.51 92.95 - 114.08	139.74 127.71 - 151.76	160.27 143.57 - 176.97
20–39	1169	0.77	63.16 55.34 - 70.98	48.63 42.40 - 55.78	17.39 13.50 - 21.28	31.00 26.51 - 35.48	53.43 44.34 - 62.52	84.60 75.25 - 93.94	124.08 106.95 - 141.22	144.70 134.77 - 154.64
40–59	1223	0.74	59.35 56.39 - 62.31	45.15 42.32 - 48.18	14.44 11.43 - 17.44	26.53 23.19 - 29.87	48.67 44.67 - 52.66	82.71 77.27 - 88.15	116.62 109.17 - 124.07	140.57 133.42 - 147.72
60–79	1083	0.18	55.31 51.57 - 59.04	44.75 41.33 - 48.46	17.36 14.06 - 20.65	28.07 23.15 - 32.99	49.47 45.38 - 53.57	72.54 67.98 - 77.11	99.52 87.46 - 111.58	121.54 107.88 - 135.19
Males										
Total, age 6–79	2662	0.23	71.23 66.18 - 76.27	56.94 52.58 - 61.67	21.45 18.48 - 24.41	37.91 34.30 - 41.53	62.77 57.64 - 67.91	94.98 85.75 - 104.22	132.16 124.41 - 139.91	152.46 140.29 - 164.63
6–11	524	0.38	77.27 69.49 - 85.05	62.51 52.92 - 73.84	23.78 15.38 - 32.19	42.53 33.16 - 51.90	68.27 57.49 - 79.05	104.54 91.10 - 117.97	132.75 118.37 - 147.12	165.76 147.16 - 184.36
12–19	505	0.00	80.79 73.23 - 88.35	66.34 59.09 - 74.49	25.98 18.93 - 33.04	46.00 38.41 - 53.59	71.15 62.50 - 79.79	110.23 99.79 - 120.66	140.31 128.27 - 152.34	162.39 137.87 - 186.91
20–39	514	0.58	71.49 62.06 - 80.91	55.71 48.03 - 64.62	17.74 9.55 - 25.93	37.46 29.82 - 45.10	63.80 54.70 - 72.90	94.15 82.81 - 105.48	132.98 120.66 - 145.31	152.00 126.99 - 177.01
40–59	578	0.17	70.60 66.79 - 74.41	55.74 52.54 - 59.13	20.33 18.00 - 22.67	35.22 30.87 - 39.57	59.62 52.69 - 66.54	100.06 91.18 - 108.93	132.92 122.02 - 143.83	157.69 145.49 - 169.90
60–79	541	0.00	62.35 56.57 - 68.12	53.26 48.83 - 58.08	23.05 20.99 - 25.12	38.10 34.93 - 41.26	55.66 50.64 - 60.68	78.57 68.07 - 89.07	109.17 93.42 - 124.92	134.63 125.94 - 143.32
Females										
Total, age 6–79	2830	0.67	54.89 49.98 - 59.80	41.93 37.73 - 46.61	14.15 11.83 - 16.47	24.50 20.59 - 28.40	44.83 39.22 - 50.43	75.76 69.46 - 82.06	108.03 97.02 - 119.04	129.34 117.91 - 140.77
6–11	510	0.59	72.17 65.34 - 78.99	57.85 52.33 - 63.95	21.14 17.13 - 25.16	36.95 29.78 - 44.12	67.26 61.21 - 73.31	101.80 88.67 - 114.93	128.17 114.51 - 141.84	150.44 132.57 - 168.30
12–19	478	0.00	74.98 65.52 - 84.44	58.77 48.72 - 70.90	19.95 9.62 - 30.29	37.06 23.00 - 51.13	68.35 57.65 - 79.05	96.59 85.96 - 107.22	136.49 121.55 - 151.42	159.25 139.82 - 178.69
20–39	655	0.92	54.76 47.23 - 62.29	42.40 36.55 - 49.20	16.40 13.18 - 19.63	27.39 21.68 - 33.09	42.13 33.36 - 50.91	72.59 60.93 - 84.25	109.00 86.77 - 131.23	132.25 112.45 - 152.06
40–59	645	1.24	48.22 44.50 - 51.94	36.66 33.16 - 40.52	11.83 9.41 - 14.26	21.00 16.26 - 25.75	40.04 34.45 - 45.64	68.24 62.54 - 73.93	94.13 87.97 - 100.30	116.21 107.42 - 125.01
60–79	542	0.37	48.84 44.10 - 53.57	38.14 33.37 - 43.60	13.48 10.83 - 16.14	22.25 17.88 - 26.63	40.59 32.32 - 48.86	66.35 59.99 - 72.71	90.11 81.62 - 98.59	112.15 102.34 - 121.97

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.10c

Selenium (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5479	0.46	65.22 62.02 - 68.41	59.09 56.45 - 61.86	34.55 32.48 - 36.62	44.10 41.95 - 46.25	57.83 54.44 - 61.22	77.17 72.66 - 81.67	102.86 97.24 - 108.49	126.49 115.33 - 137.65
6–11	1031	0.48	100.76 95.42 - 106.09	92.75 88.83 - 96.85	55.23 51.14 - 59.33	73.50 69.95 - 77.05	93.96 89.61 - 98.31	117.21 110.27 - 124.16	145.48 136.07 - 154.89	172.35 154.64 - 190.07
12–19	982	0.00	59.69 54.63 - 64.76	54.54 51.05 - 58.26	32.97 30.85 - 35.09	40.65 38.39 - 42.91	53.65 49.78 - 57.53	69.49 64.17 - 74.81	89.50 77.65 - 101.36	110.10 92.41 - 127.78
20–39	1165	0.77	59.40 55.86 - 62.94	54.26 51.23 - 57.47	32.49 29.80 - 35.18	41.07 38.34 - 43.80	52.46 49.10 - 55.81	70.03 64.61 - 75.46	95.69 85.68 - 105.70	105.82 89.37 - 122.28
40–59	1218	0.74	63.47 59.76 - 67.18	57.86 54.62 - 61.30	33.43 30.57 - 36.28	44.06 41.28 - 46.83	57.11 53.31 - 60.90	74.72 70.14 - 79.30	96.18 89.66 - 102.69	115.77 104.13 - 127.41
60–79	1083	0.18	67.72 64.13 - 71.31	62.58 59.36 - 65.98	39.22 36.16 - 42.27	47.96 44.44 - 51.48	62.20 58.85 - 65.55	79.31 75.68 - 82.94	103.88 94.94 - 112.81	119.86 108.00 - 131.72
Males										
Total, age 6–79	2653	0.23	62.01 57.89 - 66.13	56.23 53.20 - 59.43	32.65 30.54 - 34.75	42.14 39.64 - 44.65	54.81 52.22 - 57.41	73.90 68.39 - 79.40	99.62 88.50 - 110.75	119.31 100.74 - 137.87
6–11	522	0.38	101.37 96.40 - 106.35	94.89 90.92 - 99.03	59.79 56.39 - 63.19	75.85 71.99 - 79.71	96.55 89.67 - 103.43	116.56 109.63 - 123.49	144.50 132.47 - 156.53	166.60 147.01 - 186.20
12–19	504	0.00	62.10 56.24 - 67.96	55.96 52.47 - 59.69	33.02 29.27 - 36.77	41.30 38.06 - 44.55	55.18 52.79 - 57.58	70.97 64.34 - 77.61	98.51 80.63 - 116.39	121.46 92.27 - 150.66
20–39	512	0.59	55.98 51.11 - 60.85	51.03 47.38 - 54.98	29.39 26.11 - 32.68	38.20 34.65 - 41.74	49.64 46.38 - 52.89	67.10 60.84 - 73.36	91.50 78.80 - 104.20	102.79 82.03 - 123.55
40–59	574	0.17	59.71 54.49 - 64.93	54.88 50.90 - 59.18	33.25 29.69 - 36.80	43.01 38.82 - 47.21	53.66 49.64 - 57.68	69.29 61.16 - 77.42	93.00 76.64 - 109.35	110.72 87.80 - 133.65
60–79	541	0.00	60.18 55.46 - 64.90	56.16 52.13 - 60.51	35.94 32.69 - 39.19	43.09 39.91 - 46.27	55.60 51.05 - 60.16	70.15 63.33 - 76.98	87.48 80.66 - 94.29	105.32 86.34 - 124.29
Females										
Total, age 6–79	2826	0.67	68.41 65.27 - 71.54	62.09 59.23 - 65.09	36.45 34.47 - 38.43	46.32 43.71 - 48.93	62.19 58.89 - 65.48	81.02 76.08 - 85.97	105.71 101.90 - 109.52	128.41 122.68 - 134.13
6–11	509	0.59	100.11 92.65 - 107.57	90.56 85.55 - 95.86	51.82 46.62 - 57.02	70.48 65.32 - 75.64	89.84 83.96 - 95.72	118.35 107.85 - 128.85	146.65 131.15 - 162.14	179.69 145.77 - 213.62
12–19	478	0.00	57.06 52.11 - 62.01	53.02 49.10 - 57.25	32.96 30.37 - 35.54	40.26 37.90 - 42.61	52.11 46.75 - 57.47	66.94 60.26 - 73.63	85.72 76.11 - 95.34	107.42 88.06 - 126.79
20–39	653	0.92	62.85 58.13 - 67.56	57.72 53.86 - 61.86	36.40 34.15 - 38.65	44.30 40.66 - 47.94	55.51 51.10 - 59.92	72.94 66.46 - 79.41	100.24 89.41 - 111.08	113.30 92.95 - 133.65
40–59	644	1.24	67.17 62.84 - 71.51	60.96 57.21 - 64.96	35.12 31.03 - 39.22	45.22 41.59 - 48.85	63.26 59.04 - 67.49	80.12 71.83 - 88.40	100.35 90.21 - 110.50	121.22 98.04 - 144.41
60–79	542	0.37	74.65 71.10 - 78.20	69.12 65.80 - 72.61	43.00 39.87 - 46.12	54.30 50.59 - 58.01	67.87 63.96 - 71.79	87.37 81.64 - 93.09	113.01 103.68 - 122.35	135.99 121.33 - 150.66

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.1.11 Uranium (CASRN 7440-61-1)

Uranium (U) occurs naturally in variable, yet small amounts in rock, soil, water, and air. In its pure form, uranium is a silvery-white, lustrous, weakly radioactive metal that comprises approximately 0.0003% of the Earth's crust. Natural uranium is found in the environment in three radioactive isotope forms: uranium 238 (^{238}U), uranium 235 (^{235}U) and uranium 234 (^{234}U) (WHO, 2003). Uranium is not a stable element but undergoes radioactive decay, producing radioactive products as well as alpha, beta, and gamma radiation. In its natural form, uranium is only weakly radioactive.

In addition to natural sources, uranium is released through human activities such as uranium mining and processing, which creates mill tailings (ATSDR, 1999; US EPA, 2002). This uranium can combine with other chemicals in the environment to form other uranium compounds with potentially higher water solubility. Canada is the world's leading producer of uranium and accounts for approximately one-third of total global output (NRCan, 2006). Approximately 15% of Canada's electricity derives from uranium, via nuclear power.

Uranium 235 is used primarily as a fuel in nuclear power reactors, but can also be a component of nuclear weapons. Due to its high density, depleted uranium (DU), which has low radioactivity, is used for military ammunition and armour-penetrating military ordnance. Civilian uses may include aviation guidance devices, radiation shielding material for medical purposes, chemical catalysts, and dentistry. Uranium dioxide is used to extend the life of incandescent lamps, and small amounts of other uranium compounds are used for photographic toning solution, as well as stains and dyes for leather, wood, and wool (CCME, 2007; US EPA, 2002).

Due to its natural abundance in the environment, as well as its various anthropogenic uses, humans are exposed to uranium on a regular basis. Uranium intake is primarily through the ingestion of food, although drinking water and house dust can also be significant sources (CCME, 2007). The concentration of uranium in drinking water will depend on the source of the water; most surface water sources have concentrations less than 1 µg/L (CCME, 2007); however, some groundwater wells in Canada have uranium concentrations up to several hundred µg/L (Health Canada, 1995). Uranium can also be present in household dust particles with reported concentrations ranging from 0.29 to 1.33 mg/kg, and with a geometric mean of 0.55 mg/kg, as reported in a study of Ottawa, Ontario, residences (Rasmussen et al., 2001). The background intake of uranium by the general Canadian population has been estimated to range from 0.023 µg/kg body weight/day for adults to 0.078 µg/kg body weight/day for toddlers (7 months to 4 years) (CCME, 2007). The intake was determined to be primarily through ingestion of food, although soil ingestion was also a significant source of exposure for toddlers.

Following ingestion, uranium rapidly appears in the bloodstream; it is then also cleared rapidly from the bloodstream. Absorption of uranium compounds from oral ingestion is less efficient than from inhalation, as most uranium compounds are not readily absorbed by the gastrointestinal tract; the vast majority will be excreted through the feces and a smaller amount in urine within a few days (ATSDR, 1999). Following inhalation, insoluble uranium compounds can remain in the lungs for years, while soluble forms enter the blood stream where they become concentrated in the bones and kidneys (CCME, 2007). The most common test for uranium exposure is through urine, as traces can remain for months after heavy exposure, although these tests are less accurate for low exposure levels (ATSDR, 1999). Other possible methods to determine if an individual has been exposed include testing blood and hair and measuring radiation levels within the body or on the skin.

Uranium can have health effects due to both its chemical toxicity and the toxicity of the radionuclides released. Because uranium is only weakly radioactive, health effects due to radioactivity, such as carcinogenicity, are generally only observed at much higher levels than those that can result in chemical toxicity. Chemical toxicity effects are the same regardless of isotopic composition (e.g., depleted uranium versus natural uranium) (Health Canada, 2004). Background levels of uranium have not been shown to cause harmful health effects through either ingestion or inhalation (CCME, 2007; ATSDR, 1999); however, exposure to higher levels in some occupational settings has been associated with damage to bones and kidneys. The health risks from exposure to natural or depleted uranium have been shown to be related more to dosage than to duration of exposure (CCME, 2007). Health Canada (2001) has classified uranium as Group V – inadequate data for evaluation of carcinogenicity; chemical carcinogenicity of uranium has been observed only from inhalation of highly insoluble or enriched uranium compounds and not from oral exposure. The International Agency for Research on Cancer (IARC, 2001) determined that there was inadequate evidence in humans and limited evidence in laboratory animals for carcinogenicity of natural uranium. These evaluations consider only potential chemical carcinogenicity; radiation is considered carcinogenic.

Health Canada (2001) has established a tolerable daily intake (TDI) for uranium of 0.60 µg/kg body weight/day. A Guideline for Canadian Drinking Water Quality of 0.020 mg/L (20 µg/L) has been established, considering both the toxicity and the availability of treatment technologies (Health Canada, 2001).

Uranium was measured in the blood and urine of all participants aged 6–79 years in the Canadian Health Measures Survey and is presented as µg/L in blood and as both µg/L and µg/g creatinine in urine (Tables 8.1.11a, 8.1.11b, 8.1.11c). Finding a measurable amount of uranium in blood or urine is an indicator of exposure to uranium and does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for blood and urinary levels of uranium in the Canadian population.

Table 8.1.11a

Uranium – Arithmetic and geometric means, and selected percentiles of blood concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5304	93.02	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01
6–11	905	92.71	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01
12–19	941	93.94	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01
20–39	1162	91.14	—	—	<LOD	<LOD	<LOD	<LOD	<LOD <LOD - 0.01	0.01 <LOD - 0.01
40–59	1217	92.77	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD <LOD - 0.01
60–79	1079	94.81	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01
Males										
Total, age 6–79	2569	92.99	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01
6–11	457	93.65	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01
12–19	489	93.87	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD <LOD - 0.01
20–39	511	91.59	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01
40–59	575	91.48	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01
60–79	537	94.60	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01
Females										
Total, age 6–79	2735	93.05	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01
6–11	448	91.74	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01
12–19	452	94.03	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01
20–39	651	90.78	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.01 <LOD - 0.01
40–59	642	93.93	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD <LOD - 0.01
60–79	542	95.02	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.11b

Uranium – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5491	87.05	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.01 - 0.02
6–11	1034	89.36	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.01 - 0.02
12–19	983	83.11	—	—	<LOD	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.02 0.02 - 0.03
20–39	1169	87.43	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.02 <LOD - 0.03
40–59	1223	86.26	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.01 - 0.02
60–79	1082	88.91	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.02 0.01 - 0.02
Males										
Total, age 6–79	2662	85.88	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.02	0.02 0.01 - 0.03
6–11	524	89.50	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.02 <LOD - 0.03
12–19	505	80.20	—	—	<LOD	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.02 0.01 - 0.03
20–39	514	87.35	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.02	0.02 <LOD - 0.03
40–59	578	83.39	—	—	<LOD	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.02 0.01 - 0.02
60–79	541	88.91	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.02 0.01 - 0.02
Females										
Total, age 6–79	2829	88.16	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.01 - 0.02
6–11	510	89.22	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.01 0.01 - 0.02
12–19	478	86.19	—	—	<LOD	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.02 0.02 - 0.03
20–39	655	87.48	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.02	0.02 <LOD - 0.03
40–59	645	88.84	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.01 - 0.02
60–79	541	88.91	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.02	0.02 <LOD - 0.02

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.11c

Uranium (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5478	87.26	—	—	<LOD	<LOD	<LOD	<LOD	0.02 <LOD - 0.02	0.03 0.03 - 0.03
6–11	1031	89.62	—	—	<LOD	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.04 0.03 - 0.05
12–19	982	83.20	—	—	<LOD	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.02 0.02 - 0.03
20–39	1165	87.73	—	—	<LOD	<LOD	<LOD	<LOD	0.02 <LOD - 0.02	0.03 <LOD - 0.04
40–59	1218	86.62	—	—	<LOD	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.03 0.03 - 0.03
60–79	1082	88.91	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.03 0.02 - 0.04
Males										
Total, age 6–79	2653	86.17	—	—	<LOD	<LOD	<LOD	<LOD	0.02 <LOD - 0.02	0.02 0.02 - 0.03
6–11	522	89.85	—	—	<LOD	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.04 <LOD - 0.06
12–19	504	80.36	—	—	<LOD	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.02 0.01 - 0.03
20–39	512	87.70	—	—	<LOD	<LOD	<LOD	<LOD	0.02 <LOD - 0.02	0.02 <LOD - 0.04
40–59	574	83.97	—	—	<LOD	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.02 0.02 - 0.03
60–79	541	88.91	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.02 0.01 - 0.02
Females										
Total, age 6–79	2825	88.28	—	—	<LOD	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.04 0.03 - 0.04
6–11	509	89.39	—	—	<LOD	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.03 0.02 - 0.05
12–19	478	86.19	—	—	<LOD	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.02 0.02 - 0.03
20–39	653	87.75	—	—	<LOD	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.03 <LOD - 0.04
40–59	644	88.98	—	—	<LOD	<LOD	<LOD	<LOD	0.03 <LOD - 0.03	0.04 0.03 - 0.05
60–79	541	88.91	—	—	<LOD	<LOD	<LOD	<LOD	0.03 <LOD - 0.04	0.04 <LOD - 0.05

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.1.12 Vanadium (CASRN 7440-62-2)

Vanadium (V) is a naturally occurring element found in the Earth's crust and is present in iron ores, phosphate rock, and crude oil deposits. Vanadium is usually found combined with other elements and can exist in six different oxidation states, acting as either a metal or non-metal. Some common vanadium compounds include carnotite, patronite, roscoelite, and vanadinite (CCME, 1995; ATSDR, 1992). Vanadium is generally associated with organic matter; as a result, vanadium is found in crude oil and various refined petroleum products, particularly heavy fuel oil. Lesser natural sources of vanadium include erosion and weathering of rock-bearing minerals, marine aerosols, and volcanic emissions.

The bulk of vanadium, as vanadium oxides, used in Canada is imported from other countries, although there is some recovery from crude oil and petroleum products (NRCan, 2010; CCME, 1995). Vanadium is mainly used as an alloy additive in the production of various steels to increase strength, hardness, wear-resistance, and ductility. Vanadium pentoxide is used to produce ferrovanadium alloys for aircraft engines and nonferrous (titanium) alloys. In addition, vanadium is used in the manufacture of maleic anhydride, phthalic anhydride and sulphuric acid, as a catalyst in multiple processes such as petroleum cracking, and in the production of pesticides, dyes, inks, and pigments. Vanadium compounds are also used in mercury vapour lamps to modify the colour, and may be found in some paints, varnishes, corrosion inhibitors, and photographic developers (CCME, 1995; ATSDR, 1992).

The releases of vanadium oxide into the Canadian environment are mainly atmospheric emissions from various industrial activities. The major anthropogenic sources of vanadium oxide are the burning of fossil fuels and emissions from oil refineries, produced during the catalytic processing of oil (Tullar and Suffet, 1975; Lin and Chiu, 1995). Petroleum coke, which contains even higher vanadium levels than either petroleum or coal, is increasingly being used as a full or partial replacement for coal in electrical power generation (Scott and Thomas, 2007).

Due to its natural presence in the environment and releases from the combustion of fossil fuels, the general population is exposed to vanadium daily. The main source of vanadium for the general adult population is through food, although exposure can also come from air, drinking water, soil, and household dust (CCME, 1995). Grains and grain products have been estimated to contribute 13–30% of the vanadium in adult diets, while canned apple juice and cereals were the major contributors in the diets of infants and toddlers (Pennington & Jones, 1987). Soil is a major source of exposure for children under 11 years of age (Environment Canada & Health Canada, 2010). Vanadium was also used as a supplement, particularly for diabetic patients, and this use can account for much of the exposure to vanadium in certain people (Pennington & Jones, 1987). Vanadium is believed to have beneficial effects at low doses; however, its role in the body remains unclear (IOM, 2001). Health Canada (2005) has concluded that there is insufficient data to establish an estimated average requirement or adequate intake. The Health Canada multi-vitamin/mineral monograph does not allow vanadium oxide as a source of vanadium in natural health products (Health Canada, 2007).

Vanadium can be absorbed following inhalation, oral or dermal exposure, with dermal absorption being less efficient than inhalation or oral absorption. Long-term distribution of vanadium in the body is independent of the route of exposure, with bones being the main reservoir for vanadium. Ingested vanadium is mainly excreted through the feces, and the kidneys are the main route for elimination of absorbed vanadium (ACGIH, 2001). Very little of the absorbed vanadium is retained in the body; absorption of ingested vanadium is less than 5%, thus most ingested vanadium is found in the feces (IOM, 2001). As such, urinary vanadium is a biomarker of exposure to absorbed vanadium and vanadium-related compounds (e.g., vanadium oxide) (ACGIH, 2001) and the relationship between external exposure and urine concentrations is variable (ACGIH, 2001; ATSDR, 1992). Urinary vanadium provides only a qualitative indication of external exposure (ATSDR, 1992).

There is limited information regarding the effects of low-level exposure to vanadium. There is human evidence of mild gastrointestinal effects and hematological effects, such as anemia, following ingestion of vanadium compounds. Renal toxicity has been observed in animals following ingestion of vanadium compounds, but these effects have not been seen in humans (IOM, 2001). Workers chronically exposed to vanadium dusts in factories reported slight to moderate eye irritation (ATSDR, 1992). Acute inhalation exposure to high concentrations of vanadium has been associated with respiratory irritation (ATSDR, 1992). The International Agency for Research on Cancer (IARC) recently evaluated the carcinogenicity of vanadium pentoxide. It classified this substance as a possible human carcinogen (Group 2B), based on inadequate human data but sufficient evidence of respiratory cancers in rodent inhalation studies (IARC, 2006). Health Canada and Environment Canada are jointly reviewing and assessing chemical substances as part of the Chemicals Management Plan under the *Canadian Environmental Protection Act, 1999*. Vanadium oxide (CASRN 1314-62-1) was identified as a high priority substance under the Chemicals Management Plan and a draft assessment was published in March 2010 (Government of Canada, 2009; Environment Canada and Health Canada, 2010).

Health Canada (2005) has adopted Tolerable Upper Intake Levels (UL) developed by the Institute of Medicine (IOM) for vanadium that are based on renal toxicity as the critical adverse effect. The ULs for vanadium are 1.8 mg/day for adults over 19 years of age (IOM, 2001).

Vanadium was measured in the urine of all participants aged 6–79 years in the Canadian Health Measures Survey and is presented as µg/L urine and µg/g creatinine (Tables 8.1.12a, 8.1.12b). Finding a measurable amount of vanadium in urine is an indicator of exposure to vanadium and does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for urinary levels of vanadium in the Canadian population.

Table 8.1.12a

Vanadium – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5492	90.37	—	—	<LOD	<LOD	<LOD	<LOD	0.10 <LOD - 0.12	0.15 0.13 - 0.16
6–11	1034	94.68	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
12–19	983	92.98	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.14 0.12 - 0.17
20–39	1169	89.56	—	—	<LOD	<LOD	<LOD	<LOD	0.10 <LOD - 0.12	0.14 0.12 - 0.17
40–59	1223	88.72	—	—	<LOD	<LOD	<LOD	<LOD	0.11 <LOD - 0.13	0.15 0.13 - 0.17
60–79	1083	86.61	—	—	<LOD	<LOD	<LOD	<LOD	0.11 <LOD - 0.13	0.16 0.13 - 0.19
Males										
Total, age 6–79	2662	88.32	—	—	<LOD	<LOD	<LOD	<LOD	0.12 0.10 - 0.13	0.17 0.15 - 0.19
6–11	524	95.04	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
12–19	505	92.87	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.11 <LOD - 0.17
20–39	514	87.74	—	—	<LOD	<LOD	<LOD	<LOD	0.11 <LOD - 0.14	0.16 0.13 - 0.19
40–59	578	84.60	—	—	<LOD	<LOD	<LOD	<LOD	0.12 0.11 - 0.14	0.20 0.14 - 0.27
60–79	541	82.07	—	—	<LOD	<LOD	<LOD	<LOD	0.14 0.11 - 0.17	0.19 0.13 - 0.25
Females										
Total, age 6–79	2830	92.30	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.13 0.11 - 0.14
6–11	510	94.31	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
12–19	478	93.10	—	—	<LOD	<LOD	<LOD	<LOD	0.12 <LOD - 0.16	0.16 0.12 - 0.20
20–39	655	90.99	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.13 <LOD - 0.17
40–59	645	92.40	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.12 <LOD - 0.15
60–79	542	91.14	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.11 <LOD - 0.14

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.12b

Vanadium (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5479	90.58	—	—	<LOD	<LOD	<LOD	<LOD	0.21 <LOD - 0.23	0.30 0.26 - 0.33
6–11	1031	94.96	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
12–19	982	93.08	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.20 0.16 - 0.23
20–39	1165	89.87	—	—	<LOD	<LOD	<LOD	<LOD	0.19 <LOD - 0.23	0.30 0.22 - 0.37
40–59	1218	89.08	—	—	<LOD	<LOD	<LOD	<LOD	0.23 <LOD - 0.26	0.31 0.27 - 0.34
60–79	1083	86.61	—	—	<LOD	<LOD	<LOD	<LOD	0.21 <LOD - 0.24	0.31 0.26 - 0.35
Males										
Total, age 6–79	2653	88.62	—	—	<LOD	<LOD	<LOD	<LOD	0.17 0.15 - 0.19	0.25 0.20 - 0.30
6–11	522	95.40	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
12–19	504	93.06	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.18 <LOD - 0.24
20–39	512	88.09	—	—	<LOD	<LOD	<LOD	<LOD	0.17 <LOD - 0.22	0.26 0.15 - 0.37
40–59	574	85.19	—	—	<LOD	<LOD	<LOD	<LOD	0.18 0.16 - 0.19	0.26 0.21 - 0.31
60–79	541	82.07	—	—	<LOD	<LOD	<LOD	<LOD	0.16 0.14 - 0.19	0.21 0.17 - 0.24
Females										
Total, age 6–79	2826	92.43	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.33 0.28 - 0.38
6–11	509	94.50	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
12–19	478	93.10	—	—	<LOD	<LOD	<LOD	<LOD	0.15 <LOD - 0.20	0.21 0.14 - 0.29
20–39	653	91.27	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.34 <LOD - 0.45
40–59	644	92.55	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.34 <LOD - 0.45
60–79	542	91.14	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.33 <LOD - 0.42

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.1.13 Zinc (CASRN 7440-66-6)

Zinc (Zn) is one of the more common naturally occurring elements, and comprises approximately 0.004% of the Earth's crust (Browning, 1969). It is a lustrous, bluish-white, relatively soft metal in its pure state and can exist in a divalent oxidation state in various inorganic and organic compounds, which can be transformed by sunlight, water, and air. The most common zinc ore is sphalerite (ZnS), which often exists with the sulphides of other metallic elements, for example, lead, copper, cadmium, and iron (US EPA, 1976). Zinc is also found as calamine ($ZnCO_3$) in carbonate sediments; other forms of zinc are usually products of the oxidation of sphalerite (US EPA, 1976; Hem, 1970). Zinc is an essential nutrient required for the maintenance of good health.

Canada is one of the major producers and exporters of zinc globally (Health Canada, 1987; Environment Canada, 1999). Zinc is mainly used for galvanizing other metal products, such as iron and steel, in order to prevent corrosion. Other principal uses include the production of alloys, such as brass and bronze, and the manufacture of dry-cell batteries. Zinc is also used in paints, preservatives, dyes, pesticides, various cosmetic and pharmaceutical products; in the manufacture of rayons, yarns, inks, matches, tires, and other rubber products; for cementing metals in metallurgical processing; and in ornamental work (Health Canada, 1987; Environment Canada, 1999). Zinc compounds can also be found in products such as vitamin or mineral supplements, sunscreens, deodorants, and anti-dandruff shampoos.

Due to its natural abundance and prominent use in industry, everyone is exposed to small amounts of zinc. The general population is primarily exposed to zinc at low levels through the ingestion of food. Increased exposure may occur in drinking water from pipes and fittings leaching zinc. Workers in certain occupational settings, such as mining, smelting, welding, or the manufacture of zinc alloys and galvanized metals, may also be exposed to higher amounts of zinc (ATSDR, 2005). Concentrations of zinc in serum and urine are believed to increase after exposure to high doses. Serum zinc levels are commonly used as indicators of population zinc status (Hess et al., 2007). Hair and nail samples have also been suggested as having potential value for monitoring longer-term exposure (ATSDR, 2005).

Following ingestion, zinc is absorbed via the gastrointestinal tract and then transported to various tissues and organs. Between 20 and 30% of dietary zinc is absorbed, with enhanced absorption occurring under conditions of zinc deficiency (Department of National Health and Welfare, 1983). Over 85% of the total body zinc is found in skeletal muscle and bone (IOM, 2001). The primary route of excretion from the body is via the gastrointestinal tract, and this includes unabsorbed dietary zinc, a small amount from sloughing of intestinal epithelial cells, and zinc from biliary and pancreatic origin. Under normal circumstances, about 0.5 mg of zinc may be lost in perspiration with an equal amount lost in daily urine (Prasad, 1983).

Zinc is an essential trace element in humans, forming a component of many metalloenzymes and other substances in the body. It aids in connective tissue formation, the maintenance of healthy skin, immune system functioning, and the metabolism of carbohydrates, fats, and proteins (Health Canada, 1987; Environment Canada, 1999; Health Canada, 2007). Insufficient zinc intake may lead to dermatitis, anorexia, reduced growth, poor healing of wounds, reduced reproductive ability, reduced mental function, and impairment of the immune system (ATSDR, 2005). The Recommended Dietary Allowance (RDA) for Canadians is 2 mg/day for young infants, 3–7 mg/day for children to age 13, and from the age of 14, 11 mg/day for males and 8 mg/day for females (Health Canada, 2005).

Exposure to high levels of zinc can affect health. Acute zinc toxicity is usually the result of taking excess vitamin or mineral supplements or drinking acidic beverages stored for long periods of time in galvanized containers (WHO, 2003). Large doses of zinc can cause stomach cramps, nausea, and vomiting (ATSDR, 2005). Ingesting high levels of zinc can inhibit absorption of copper into the blood stream (WHO, 2003; US EPA, 2005) and chronic zinc toxicosis, manifesting as a copper deficiency, can occur. Effects of inhaled zinc are generally limited to the respiratory tract and vary depending on the specific chemical composition (ATSDR, 2005). Inhalation of large quantities of zinc dust or fumes, such as in occupational settings, can result in a reversible short-term condition lasting a few days known as "metal fume fever," which begins with a dry throat and coughing and leads to chest pain, coughing, and shortness of breath.

Health Canada (2005) has adopted Tolerable Upper Intake Levels (UL) developed by the Institute of Medicine (IOM) for zinc, which account for both its essentiality and its potential toxicity. The ULs for zinc are 4 mg/day for infants 0–6 months old, 5 mg/day for infants 7–12 months old, 7 mg/day for children 1–3 years old, 12 mg/day for children 4–8 years old, 23 mg/day for children 9–13 years old, 34 mg/day for adolescents 14–18 years old, and 40 mg/day for adults (IOM, 2001). Health Canada (1987) has established an aesthetic objective for drinking water of ≤5.0 mg/L based on taste; this guideline was also deemed protective of adverse health effects.

Health Canada and Environment Canada assessed the metals (largely in the form of particulates) copper, zinc, nickel, lead, cadmium, chromium, and arsenic, contained in emissions from zinc plants, and concluded they were of concern to the environment and to human health (Environment Canada & Health Canada, 2001).

In a study carried out in British Columbia on non-smoking adults aged 30–65, the geometric mean and 95th percentile concentrations of zinc in urine were 285.43 μg/g creatinine and 607.83 μg/g creatinine, respectively (Clark et al., 2007).

Zinc was measured in the blood and urine of all participants aged 6–79 years in the Canadian Health Measures Survey and is presented as μg/L in blood and as both μg/L and μg/g creatinine in urine (Tables 8.1.13a, 8.1.13b, 8.1.13c). Finding a measurable amount of zinc in blood or urine is an indicator of exposure to zinc and does not necessarily mean that an adverse health effect will occur. Since it is an essential nutrient, its presence is expected. These data provide reference ranges for blood and urinary levels of zinc in the Canadian population.

Table 8.1.13a

Zinc – Arithmetic and geometric means, and selected percentiles of blood concentrations (μg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5319	0.00	6.44 6.35 - 6.53	6.37 6.28 - 6.46	5.23 5.12 - 5.34	5.80 5.73 - 5.87	6.42 6.35 - 6.49	7.06 6.96 - 7.16	7.61 7.50 - 7.72	7.91 7.79 - 8.03
6–11	910	0.00	5.29 5.17 - 5.40	5.24 5.12 - 5.36	4.42 4.27 - 4.56	4.78 4.62 - 4.94	5.26 5.12 - 5.40	5.73 5.63 - 5.83	6.18 6.03 - 6.34	6.51 6.37 - 6.65
12–19	945	0.00	6.03 5.93 - 6.13	5.96 5.86 - 6.07	4.94 4.75 - 5.13	5.45 5.34 - 5.55	6.01 5.84 - 6.17	6.54 6.44 - 6.64	7.15 7.07 - 7.23	7.44 7.23 - 7.64
20–39	1165	0.00	6.48 6.37 - 6.58	6.41 6.31 - 6.52	5.34 5.17 - 5.51	5.83 5.72 - 5.94	6.44 6.35 - 6.54	7.06 6.94 - 7.18	7.58 7.45 - 7.72	7.87 7.65 - 8.09
40–59	1220	0.00	6.59 6.49 - 6.70	6.54 6.43 - 6.65	5.53 5.36 - 5.70	6.03 5.91 - 6.15	6.53 6.38 - 6.68	7.11 6.99 - 7.24	7.66 7.54 - 7.78	7.97 7.73 - 8.21
60–79	1079	0.00	6.75 6.63 - 6.86	6.68 6.57 - 6.79	5.65 5.49 - 5.82	6.18 6.06 - 6.30	6.72 6.57 - 6.87	7.31 7.15 - 7.48	7.82 7.67 - 7.98	8.11 7.96 - 8.25
Males										
Total, age 6–79	2576	0.00	6.68 6.57 - 6.78	6.61 6.50 - 6.71	5.39 5.32 - 5.45	6.09 6.00 - 6.17	6.72 6.59 - 6.86	7.32 7.20 - 7.45	7.77 7.65 - 7.90	8.10 7.91 - 8.29
6–11	459	0.00	5.21 5.06 - 5.36	5.17 5.02 - 5.32	4.39 4.22 - 4.56	4.68 4.53 - 4.83	5.14 4.96 - 5.32	5.64 5.50 - 5.78	6.15 5.92 - 6.37	6.39 6.14 - 6.65
12–19	489	0.00	6.14 6.00 - 6.28	6.06 5.92 - 6.21	4.88 4.60 - 5.16	5.44 5.29 - 5.59	6.11 5.88 - 6.34	6.86 6.66 - 7.06	7.26 7.06 - 7.45	7.88 7.42 - 8.33
20–39	514	0.00	6.77 6.63 - 6.91	6.72 6.58 - 6.86	5.66 5.32 - 5.99	6.21 6.04 - 6.38	6.78 6.60 - 6.95	7.38 7.25 - 7.51	7.76 7.55 - 7.98	7.98 7.69 - 8.27
40–59	577	0.00	6.91 6.76 - 7.06	6.86 6.71 - 7.02	5.93 5.75 - 6.11	6.39 6.25 - 6.53	6.86 6.67 - 7.05	7.43 7.24 - 7.62	7.83 7.60 - 8.07	8.26 7.93 - 8.59
60–79	537	0.00	7.00 6.87 - 7.12	6.94 6.82 - 7.06	5.95 5.84 - 6.05	6.42 6.29 - 6.55	6.95 6.78 - 7.12	7.54 7.36 - 7.73	7.95 7.83 - 8.07	8.25 8.04 - 8.46
Females										
Total, age 6–79	2743	0.00	6.19 6.11 - 6.28	6.13 6.05 - 6.22	5.14 5.02 - 5.26	5.63 5.53 - 5.73	6.19 6.10 - 6.27	6.72 6.61 - 6.83	7.19 7.10 - 7.29	7.58 7.43 - 7.74
6–11	451	0.00	5.36 5.24 - 5.49	5.32 5.19 - 5.45	4.44 4.17 - 4.70	4.90 4.72 - 5.08	5.35 5.22 - 5.48	5.81 5.68 - 5.95	6.28 6.04 - 6.52	6.57 6.41 - 6.73
12–19	456	0.00	5.90 5.80 - 6.00	5.86 5.75 - 5.97	5.02 4.85 - 5.19	5.44 5.33 - 5.56	5.90 5.74 - 6.07	6.37 6.24 - 6.50	6.81 6.61 - 7.01	7.03 6.83 - 7.23
20–39	651	0.00	6.18 6.03 - 6.33	6.12 5.97 - 6.26	5.12 4.91 - 5.32	5.58 5.44 - 5.73	6.18 5.98 - 6.38	6.67 6.53 - 6.80	7.12 6.98 - 7.27	7.51 7.03 - 7.99
40–59	643	0.00	6.28 6.17 - 6.40	6.24 6.12 - 6.35	5.29 5.10 - 5.49	5.75 5.64 - 5.86	6.26 6.14 - 6.38	6.73 6.57 - 6.89	7.22 7.07 - 7.37	7.53 7.35 - 7.72
60–79	542	0.00	6.52 6.37 - 6.66	6.46 6.32 - 6.60	5.44 5.23 - 5.64	5.96 5.76 - 6.15	6.46 6.35 - 6.58	7.01 6.85 - 7.18	7.59 7.37 - 7.81	7.97 7.61 - 8.33

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.13b

Zinc – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5492	0.78	389.50 372.15 - 406.84	254.02 238.43 - 270.63	67.64 58.18 - 77.10	136.98 121.05 - 152.90	274.33 259.41 - 289.25	524.69 499.26 - 550.12	835.11 789.83 - 880.38	1087.90 1027.88 - 1147.93
6–11	1034	0.19	388.46 354.62 - 422.31	293.15 260.64 - 329.70	98.41 74.26 - 122.56	189.91 165.54 - 214.28	326.86 284.54 - 369.18	519.34 470.86 - 567.81	752.89 682.83 - 822.95	860.12 788.47 - 931.77
12–19	983	0.10	541.80 490.58 - 593.03	396.80 364.64 - 431.79	126.10 103.18 - 149.03	228.41 197.48 - 259.34	454.02 417.17 - 490.87	729.80 683.87 - 775.74	1022.99 878.51 - 1167.46	1370.65 1085.36 - 1655.95
20–39	1169	1.20	341.28 315.72 - 366.84	218.60 198.90 - 240.25	57.22 44.61 - 69.84	119.22 97.03 - 141.40	224.21 189.70 - 258.72	456.87 408.40 - 505.34	763.54 681.11 - 845.98	1039.90 902.14 - 1177.66
40–59	1223	1.39	372.49 342.68 - 402.29	234.12 214.57 - 255.44	59.19 47.15 - 71.22	119.50 101.77 - 137.24	249.63 221.13 - 278.12	497.64 440.06 - 555.22	818.13 648.43 - 987.82	1131.81 971.11 - 1292.51
60–79	1083	0.83	411.29 382.07 - 440.51	275.36 256.11 - 296.05	82.44 60.51 - 104.38	154.56 131.51 - 177.61	293.09 269.64 - 316.54	547.78 506.22 - 589.34	866.66 758.06 - 975.27	1100.93 977.48 - 1224.38
Males										
Total, age 6–79	2662	0.34	461.94 445.14 - 478.73	326.35 309.83 - 343.75	103.22 90.68 - 115.76	189.43 172.28 - 206.57	351.41 329.55 - 373.28	598.80 569.89 - 627.71	981.47 920.98 - 1041.96	1225.41 1144.01 - 1306.82
6–11	524	0.38	387.61 340.39 - 434.83	295.56 244.90 - 356.70	105.06 69.99 - 140.13	199.21 164.40 - 234.02	329.10 259.57 - 398.64	519.20 446.97 - 591.42	744.35 652.79 - 835.91	834.04 774.92 - 893.16
12–19	505	0.00	585.00 532.21 - 637.79	450.81 411.00 - 494.49	160.77 136.82 - 184.72	270.56 234.14 - 306.98	481.77 433.77 - 529.77	748.34 705.33 - 791.35	1089.70 929.08 - 1250.32	1384.66 1115.86 - 1653.47
20–39	514	0.39	431.81 383.95 - 479.66	294.09 250.93 - 344.68	84.58 53.62 - 115.53	154.95 114.76 - 195.14	307.62 242.36 - 372.88	572.85 491.42 - 654.27	947.98 759.13 - 1136.82	1218.51 1056.97 - 1380.05
40–59	578	0.52	456.47 413.14 - 499.80	317.86 293.41 - 344.35	95.76 73.40 - 118.12	187.55 172.71 - 202.40	349.03 306.29 - 391.77	574.18 510.00 - 638.35	986.86 829.27 - 1144.45	1258.30 945.54 - 1571.05
60–79	541	0.37	476.42 423.12 - 529.71	348.80 313.37 - 388.23	116.75 90.93 - 142.57	215.06 196.65 - 233.46	360.93 318.60 - 403.27	589.76 492.47 - 687.05	991.53 853.14 - 1129.92	1162.98 782.12 - 1543.85
Females										
Total, age 6–79	2830	1.20	317.15 291.83 - 342.47	197.78 180.16 - 217.13	51.06 44.72 - 57.40	102.41 84.83 - 120.00	210.14 192.04 - 228.24	423.23 385.27 - 461.20	685.19 630.07 - 740.32	936.85 833.84 - 1039.86
6–11	510	0.00	389.36 352.47 - 426.25	290.62 264.18 - 319.71	92.62 73.27 - 111.98	183.45 155.42 - 211.48	324.31 289.38 - 359.24	520.08 464.19 - 575.97	761.99 651.59 - 872.40	925.23 782.31 - 1068.15
12–19	478	0.21	494.50 435.01 - 554.00	345.05 304.40 - 391.13	93.97 61.52 - 126.43	180.75 143.01 - 218.48	393.57 329.56 - 457.59	705.25 595.92 - 814.57	1004.23 795.61 - 1212.85	1300.18 869.44 - 1730.92
20–39	655	1.83	249.94 222.66 - 277.22	162.05 145.18 - 180.88	46.20 35.99 - 56.41	87.02 67.66 - 106.38	169.66 146.54 - 192.77	350.85 297.03 - 404.66	549.37 448.24 - 650.49	669.79 595.21 - 744.37
40–59	645	2.17	289.41 242.29 - 336.54	173.01 146.71 - 204.03	46.99 35.73 - 58.25	86.59 66.12 - 107.06	186.74 147.29 - 226.18	362.37 292.95 - 431.79	650.00 537.73 - 762.26	948.58 672.12 - 1225.05
60–79	542	1.29	351.46 317.68 - 385.23	221.60 191.27 - 256.75	58.60 41.41 - 75.79	120.15 83.43 - 156.88	225.91 186.39 - 265.44	501.97 423.11 - 580.83	715.69 649.42 - 781.96	938.49 754.99 - 1121.99

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.13c

Zinc (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5479	0.78	376.88 367.01 - 386.74	307.11 296.99 - 317.57	132.01 123.37 - 140.66	204.85 194.70 - 214.99	323.01 313.88 - 332.14	482.54 462.56 - 502.52	667.09 637.53 - 696.64	847.45 812.52 - 882.39
6–11	1031	0.19	508.21 482.23 - 534.18	451.08 426.43 - 477.16	242.02 214.67 - 269.37	333.59 310.42 - 356.75	465.00 442.34 - 487.66	612.18 580.30 - 644.06	828.72 773.58 - 883.87	966.87 893.49 - 1040.24
12–19	982	0.10	401.99 379.16 - 424.83	345.37 321.96 - 370.48	166.20 144.16 - 188.24	244.88 220.64 - 269.13	360.37 336.61 - 384.13	515.23 493.14 - 537.32	669.15 606.02 - 732.29	835.32 738.01 - 932.64
20–39	1165	1.20	289.02 273.70 - 304.33	243.79 228.57 - 260.02	111.27 95.73 - 126.81	170.17 155.21 - 185.14	254.85 235.15 - 274.55	363.28 346.88 - 379.67	510.11 469.32 - 550.89	602.17 567.71 - 636.62
40–59	1218	1.40	370.79 349.38 - 392.20	299.94 283.82 - 316.99	129.51 114.98 - 144.04	198.61 187.87 - 209.36	321.91 298.47 - 345.35	471.57 426.00 - 517.14	662.08 610.78 - 713.39	824.95 763.25 - 886.66
60–79	1083	0.83	476.50 452.55 - 500.46	385.06 361.61 - 410.02	166.35 133.65 - 199.05	262.25 230.99 - 293.50	393.84 366.42 - 421.27	597.37 555.22 - 639.53	885.74 840.83 - 930.65	1078.79 974.99 - 1182.59
Males										
Total, age 6–79	2653	0.34	379.64 365.76 - 393.51	321.99 308.01 - 336.59	148.40 130.65 - 166.15	224.95 207.77 - 242.14	331.39 314.75 - 348.02	486.82 459.38 - 514.26	649.38 619.45 - 679.32	814.21 772.52 - 855.90
6–11	522	0.38	502.40 463.47 - 541.34	448.14 419.58 - 478.65	237.86 214.59 - 261.13	335.61 313.06 - 358.16	464.89 433.86 - 495.93	616.58 563.64 - 669.52	812.03 736.22 - 887.85	910.75 827.78 - 993.71
12–19	504	0.00	431.20 403.54 - 458.85	379.89 351.76 - 410.26	200.29 170.69 - 229.88	274.39 249.22 - 299.57	388.97 357.23 - 420.70	543.41 518.24 - 568.58	673.26 581.98 - 764.55	857.96 741.98 - 973.93
20–39	512	0.39	310.59 286.06 - 335.12	268.98 245.69 - 294.48	129.24 109.44 - 149.03	187.20 162.48 - 211.91	275.21 229.26 - 321.16	384.91 345.99 - 423.82	545.74 476.42 - 615.07	612.03 574.90 - 649.15
40–59	574	0.52	366.97 343.80 - 390.15	312.79 297.78 - 328.56	147.54 134.94 - 160.15	210.84 190.04 - 231.64	326.66 306.49 - 346.82	449.92 409.48 - 490.36	645.30 573.87 - 716.73	743.35 643.79 - 842.92
60–79	541	0.37	444.38 412.22 - 476.55	367.83 337.21 - 401.23	170.60 143.09 - 198.11	243.30 211.01 - 275.59	375.49 346.17 - 404.81	558.60 514.61 - 602.60	835.16 737.27 - 933.05	1000.82 858.72 - 1142.92
Females										
Total, age 6–79	2826	1.20	374.12 358.22 - 390.03	292.96 280.41 - 306.08	117.51 105.54 - 129.49	186.15 170.87 - 201.44	311.88 292.40 - 331.36	478.30 450.44 - 506.16	696.74 647.07 - 746.41	885.78 809.45 - 962.11
6–11	509	0.00	514.32 489.42 - 539.21	454.20 425.86 - 484.42	242.23 197.42 - 287.05	328.49 297.34 - 359.65	464.72 440.03 - 489.42	610.85 579.50 - 642.20	833.79 743.79 - 923.80	1012.11 900.92 - 1123.30
12–19	478	0.21	370.10 344.44 - 395.77	311.25 289.58 - 334.55	149.65 131.99 - 167.30	199.84 160.00 - 239.67	308.65 289.07 - 328.23	472.12 419.99 - 524.26	657.23 579.28 - 735.18	769.12 684.97 - 853.27
20–39	653	1.84	267.27 243.29 - 291.26	220.78 203.16 - 239.94	94.46 83.79 - 105.14	150.41 141.15 - 159.67	229.69 207.34 - 252.05	342.71 305.53 - 379.89	468.71 397.81 - 539.60	575.71 490.28 - 661.15
40–59	644	2.17	374.56 341.24 - 407.87	287.80 261.44 - 316.82	110.09 88.68 - 131.49	182.12 148.70 - 215.54	303.24 262.47 - 344.02	496.20 446.64 - 545.76	711.46 630.00 - 792.91	904.62 640.34 - 1168.90
60–79	542	1.29	506.01 469.41 - 542.61	401.60 372.05 - 433.48	151.98 91.69 - 212.28	290.14 248.21 - 332.07	425.47 385.81 - 465.12	627.28 591.96 - 662.60	921.54 821.27 - 1021.82	1125.33 939.16 - 1311.50

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.2 ORGANOCHLORINES

8.2.1 Aldrin (CASRN 309-00-2)

Aldrin is an organochlorine insecticide with the systematic name 1,2,3,4,10,10-hexachloro-1,4,4α,5,8,8α-hexahydro-1,4-endo,exo-5,8-dimethanonaphthalene, and the chemical formula $C_{12}H_8Cl_6$. Aldrin is closely related to dieldrin (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4α,5,6,7,8,8α-octahydro-1,4-endo, exo-5,8-dimethanonaphthalene; chemical formula $C_{12}H_8Cl_6O$), and may be converted to dieldrin in the environment or through metabolic processes in the human body (ATSDR, 2002).

Aldrin is a synthetic chemical that does not occur naturally in the environment. It was manufactured for use only in pesticide applications (both agricultural and non-agricultural) and is no longer produced or imported into North America (ATSDR, 2002; Health Canada, 1995).

Aldrin was primarily used as an insecticide on crops, such as corn and cotton, from the 1950s through the 1970s, as well as for domestic, forestry, and industrial use (ATSDR, 2002; Health Canada, 1995). Aldrin is a soil insecticide that works by contact and ingestion (Hayes, 1982). Registration and use of aldrin decreased significantly after the mid-1970s, although limited use for subterranean termite control continued until the mid-1980s (Health Canada, 1995). Aldrin and dieldrin were not registered for use in Canada after 1990 (Agriculture Canada, 1990).

Aldrin previously entered the environment from treated crops and from use by exterminators, and may still persist in soils where it was applied. Current sources include spills and leaks from waste sites, as well as redistribution to previously uncontaminated areas by processes such as atmospheric transport and leaching to groundwater (ATSDR, 2002). There is no current potential for industrial releases within Canada.

The primary routes of exposure for the public are through ingestion of food grown in soil contaminated with aldrin or ingestion of animal tissue that has accumulated aldrin. Exposure may also occur through ingestion of drinking water, inhalation, or dermal contact with media containing aldrin, although the potential for these pathways is substantially lower (ATSDR, 2002). Exposure to aldrin and its metabolite dieldrin are often highest in individuals who consume large amounts of fish or fat tissue from marine mammals. Canadians living in Northern communities are often especially susceptible to consuming greater than average amounts of aldrin and dieldrin due to their traditional diets, which include large quantities of fish and marine mammals. Increased inhalation exposure can also result from residual volatilization of aldrin in homes with foundations that were treated for termite control (ATSDR, 2002).

Even though aldrin is no longer in use, it may still be found in food products since it persists in agricultural soil where it was previously used. Exposure in humans is primarily from ingestion of these food products (ATSDR, 2002). Aldrin was last analyzed in the Canadian Total Diet Study in 1985, although it was not detected in any foods (ATSDR, 2002). It has not been analyzed in more recent Total Diet Studies (TDS) (Health Canada, 2009). Dieldrin continues to be detected in a variety of foods, including fruit, vegetables, dairy products and fish, although concentrations have been decreasing since the use of dieldrin was phased out (ATSDR, 2002; Health Canada, 2009). The TDS results from 1978 showed that detectable residue levels of dieldrin in food were generally below 1 µg/kg (McLeod et al., 1980).

Due to the low solubility of both aldrin and dieldrin, the capability of these chemicals to contaminate either surface water or groundwater is considered to be very low. Aldrin and dieldrin concentrations are usually less than 0.01 µg/L in drinking water, and these compounds are rarely present in groundwater (WHO, 2003).

While aldrin is normally rapidly metabolized, dieldrin bioaccumulates and biomagnifies in fish and marine mammal species. Concentrations of dieldrin in seals in northern Canada did not decrease in concentration between 1972 and 1991 (Addison & Smith, 1998).

Aldrin is rapidly metabolized to dieldrin once absorbed in the body. Dieldrin is initially distributed throughout the body, but within a few hours it is redistributed primarily to fat, with smaller amounts being redistributed to the kidneys and lymph nodes (ATSDR, 2002). Dieldrin is estimated to have a biological elimination half-life of approximately 369 days (ATSDR, 2002). Excretion of dieldrin is primarily in feces via bile, but it is also excreted in smaller amounts in urine and in breast milk (ATSDR, 2002). Aldrin and dieldrin can both be measured in blood serum or plasma, as well as in breast milk. Since aldrin is rapidly metabolized into dieldrin upon absorption into the body (Health Canada, 1995), the aldrin concentration is only an indicator of recent exposure, and dieldrin is a more reliable marker of historic or chronic exposure to aldrin. In a pilot study carried out in 1992 in two regions of the Great Lakes area of Ontario, 232 anglers were assessed for the levels of various environmental contaminants in blood and urine samples. While aldrin was not assessed, dieldrin levels were measured; the geometric mean and maximum concentrations of dieldrin in blood plasma were 9.72 µg/kg plasma lipid and 45.7 µg/kg plasma lipid, respectively (Kearney et al., 1995).

Short-term exposure to high concentrations of aldrin has been associated with effects on the central nervous system and the liver (WHO, 2003). Cases of accidental poisonings have resulted in convulsions, seizures, or death (ATSDR, 2002). Long-term exposure to concentrations commonly encountered by the general population through dietary exposure is not thought to pose a health hazard (IPCS, 1999). Chronic exposure to moderate concentrations of aldrin may result in symptoms such as headaches, dizziness, irritability, and vomiting (ATSDR, 2002). Long-term exposure to aldrin and dieldrin has been shown to cause adverse hepatic effects in rats and dogs (ATSDR, 2002).

The United States Environmental Protection Agency classifies aldrin as a probable human carcinogen (Group B2), based on observed liver neoplasms in mice (US EPA, 1993). The International Agency for Research on Cancer has determined aldrin to be Group 3, "not classifiable as to its carcinogenicity to humans" due to inadequate human data and only limited animal data (IARC, 1987). Aldrin and dieldrin are classified as persistent organic pollutants (POP) by the Stockholm Convention, an international agreement to ban or severely restrict the production and use of POPs (UNEP, 2008).

An acceptable daily intake (ADI) for aldrin and dieldrin combined of 0.1 µg/kg body weight per day has been adopted by Health Canada (2007). This value was based on a No Observed Adverse Effect Level (NOAEL) of 0.025 mg/kg body weight/day in rats for hepatotoxic effects. The Guideline for Canadian Drinking Water Quality for aldrin and dieldrin is 0.007 mg/L (Health Canada, 1995).

Blood plasma levels of aldrin were measured in a subset of the population aged 20–79 years participating in the Canadian Health Measures Survey and are presented as µg/L plasma and µg/kg lipid (Tables 8.2.1a, 8.2.1b). Participants were selected within the specified age range to be a representative sample of the Canadian population. Finding a measurable amount of aldrin in blood plasma is an indicator of recent exposure to aldrin and does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for blood plasma levels of aldrin in the Canadian population.

Table 8.2.1a

Aldrin – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	526	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	596	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	544	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	801	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	865	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	286	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	315	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	264	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

■ Table 8.2.1b

Aldrin (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1664	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	525	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	596	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	543	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	801	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	863	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	285	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	315	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	263	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

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8.2.2 Chlordane (CASRN 57-74-9)

Chlordane ($C_{10}H_6Cl_8$) is an organochlorine pesticide that was introduced in the 1940s for agricultural and residential applications in Canada (CCME, 2004). Technical chlordane (CASRN 12789-03-6) is a mixture of over 140 structurally related organochlorine compounds. Some of the major components include:

- α-chlordane, or (1α,2α,3aα,4β,7β,7aα)-1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methano-1H-indene (CASRN 5103-71-9)
- γ-chlordane, or (1α,2β,3aα,4β,7β,7aα)-1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methano-1H-indene (CASRN 5103-74-2)
- *cis*-nonachlor, or (1α,2α,3α,3aα,4β,7β,7aα)-1,2,3,4,5,6,7,8,8-nonachloro-2,3,3a,4,7,7a-hexahydro-4,7-methano-1H-indene (CASRN 5103-73-1)
- *trans*-nonachlor, or (1α,2β,3α,3aα,4β,7β,7aα)-1,2,3,4,5,6,7,8,8-nonachloro-2,3,3a,4,7,7a-hexahydro-4,7-methano-1H-indene (CASRN 39765-80-5)

The most important metabolite of chlordane is oxychlordane (2,3,4,5,6,6a,7,7-octachloro-1a,1b,5,5a,6,6a-hexahydro-2,5-methano-2H-indeno(1,2-b)oxirene) (CASRN 27304-13-8).

Chlordane is a synthetic chemical mixture with no natural sources, and is released to the environment solely by anthropogenic activities. Chlordane was used as a broad-based insecticide for a variety of agricultural crops, for residential applications such as lawns and gardens, as a fumigating agent, and for underground application to homes as termite prevention (ATSDR, 1994; Environment Canada, 2008). Chlordane was never manufactured in Canada and its use was discontinued in 1998. It is no longer registered for use as a pesticide in Canada and cannot be imported to or exported from Canada (Environment Canada, 2005). Production, sale, and use of chlordane in the United States have also been prohibited since 1988 (ATSDR, 1994).

Chlordane has been detected in all environmental media. While its use has been discontinued in Canada, chlordane compounds are very resistant to degradation, and long-range transport of these chemicals is possible (ATSDR, 1994).

The primary source of exposure to the public is through ingestion of foods containing traces of chlordane (ATSDR, 1994), although individuals living in homes previously treated with chlordane may be exposed to elevated indoor air concentrations (ATSDR, 1994). Chlordane can remain for decades in soils where it was previously applied, and food products grown in these soils continue to show detectable concentrations long after use was discontinued in Canada. Occupational exposure may occur with individuals working in agricultural areas where chlordane has previously been applied. Due to the bans on use in Canada and the United States, environmental concentrations are expected to continue to gradually decrease over time, and the potential for new industrial releases is low.

Various foods from the 1993 to 1998 Health Canada Total Diet Studies (TDS), including potato chips, fresh and canned fish, peanut butter, peanuts, candy, microwave popcorn, cucumbers, flour, cookies, and melons, had detectable levels (low parts per billion [ppb]) of chlordane chemicals (Health Canada, 2009a).

Chlordane products generally remain in soil after application. Due to the estimated one-year half-life in soil (UNEP, 2007), strong adsorption onto organic substrates, and very low solubility in water, chlordane residues can persist in soils for over 20 years (ATSDR, 1994). Chlordane may enter water bodies either through leaching from soils and subsequent transport through groundwater, or by deposition from the atmosphere; however, due to their low solubility, once in the water, chlordane tends to bind to sediments (UNEP, 2007). Chlordane compounds are not normally detected in drinking water (WHO, 2004).

Chlordane is absorbed after oral, dermal, and inhalation exposure. Once absorbed, chlordane isomers are preferentially metabolized into oxychlordane, and to a lesser extent, to heptachlor. Biological samples tend to contain primarily oxychlordane and nonachlor compounds (CDC, 2005). Elimination of these chemicals from the body occurs over months to years, and breast milk is a major excretion route in lactating women (CDC, 2005). Samples of maternal blood plasma from the Canadian Arctic in 1994–1999 (Butler Walker et al., 2003) consistently had detectable levels of chlordane products; mean concentrations were 0.05 μg/L for cis-nonachlor (detected in 48.05% of samples), 0.25 μg/L for trans-nonachlor (detected in 98.18% of samples), and 0.23 μg/L for oxychlordane (detected in 95.58% of samples). In a pilot study carried out in 1992 in two regions of the Great Lakes area of Ontario, 232 anglers were assessed for the levels of a number of chlordane metabolites in blood plasma. Geometric mean and maximum concentrations (respectively) were 17.1 μg/kg plasma lipid and 48.4 μg/kg plasma lipid for oxychlordane, and 21.0 μg/kg plasma lipid and 116.2 μg/kg plasma lipid for trans-nonachlor (Kearney et al., 1995).

Exposure to high doses of chlordane can result in effects on the nervous system, digestive system, and liver (ATSDR, 1994). The toxicity of chlordane contamination is significantly influenced by environmental and biological degradation processes that have taken place, which are often isomer-specific (ATSDR, 1994).

Chlordane pesticides are not registered for use or sale in Canada by the Pest Management Regulatory Agency (Health Canada, 2009b). Chlordane is classified as a persistent organic pollutant (POP) and as a severe marine pollutant by the Stockholm Convention, an international agreement to ban or severely restrict the production and use of POPs (UNEP, 2008). Health Canada and Environment Canada have conducted a screening assessment that concluded technical grade chlordane is of concern to non-human organisms, but that no further action is required for this substance since no manufacturing or importing of chlordane was reported by Canadian industry (Environment Canada, 2008).

The International Agency for Research on Cancer (IARC) classifies chlordane as a possible human carcinogen (Group 2B) based on inadequate evidence in humans and sufficient evidence in laboratory animals, specifically liver cancer observed in some rodent studies (IARC, 2001). The United States Environmental Protection Agency (US EPA, 1997) has classified chlordane as Group B2, a probable human carcinogen.

A provisional tolerable daily intake (pTDI) for the total sum of chlordane and related chlordane isomer/metabolites of 0.05 µg/kg body weight/day has been adopted by Health Canada (2007). The World Health Organization (WHO, 2004) has established an allowable daily intake (ADI) of 0.0005 mg/kg body weight/day for technical chlordane, based on liver toxicity observed in long-term rat studies.

Blood plasma levels of α-chlordane, γ-chlordane, *cis*-nonachlor, *trans*-nonachlor, and oxychlordane were measured in a subset of the Canadian Health Measures Survey (CHMS) population aged 20–79 years and are presented as µg/L plasma and µg/kg lipid (Tables 8.2.2.1a – 8.2.2.5b). Participants were selected within the specified age range to be a representative sample of the Canadian population. Finding a measurable amount of chlordane or its metabolites in blood plasma is an indicator of exposure to chlordane and does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for blood plasma levels of α-chlordane, γ-chlordane, *cis*-nonachlor, *trans*-nonachlor, and oxychlordane in the Canadian population.

8.2.2.1 α-Chlordane

■ Table 8.2.2.1a

α-Chlordane – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	526	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	596	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	544	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	801	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	865	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	286	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	315	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	264	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.2.2.1b

α-Chlordane (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95% CI	G.M. 95% CI	10th 95% CI	25th 95% CI	50th 95% CI	75th 95% CI	90th 95% CI	95th 95% CI
Total, age 20–79	1664	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	525	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	596	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	543	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	801	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	863	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	285	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	315	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	263	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.2.2.2 γ-Chlordane

Table 8.2.2.2a

γ-Chlordane – Arithmetic and geometric means, and selected percentiles of plasma concentrations (μg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	99.70	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	526	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	596	99.50	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	544	99.63	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	801	99.75	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	99.29	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	865	99.65	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	286	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	315	99.05	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	264	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.2.2.2b

γ-Chlordane (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95% CI	G.M. 95% CI	10th 95% CI	25th 95% CI	50th 95% CI	75th 95% CI	90th 95% CI	95th 95% CI
Total, age 20–79	1664	99.82	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	525	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	596	99.50	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	543	99.82	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	801	99.75	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	99.29	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	863	99.88	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	285	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	315	99.05	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	263	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.2.2.3 *cis*-Nonachlor

Table 8.2.2.3a

cis-Nonachlor – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	49.04	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.01 0.01 - 0.02	0.02 0.01 - 0.02
20–39	526	88.40	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.01 0.01 - 0.01
40–59	596	49.16	—	—	<LOD	<LOD	0.01 <LOD - 0.01	0.01 0.01 - 0.01	0.01 0.01 - 0.02	0.02 0.01 - 0.02
60–79	546	10.99	0.01 0.01 - 0.02	0.01 0.01 - 0.01	<LOD	0.01 0.01 - 0.01	0.01 0.01 - 0.01	0.02 0.01 - 0.02	0.02 0.02 - 0.03	0.03 0.02 - 0.04
Males										
Total, age 20–79	801	45.32	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.01 0.01 - 0.02	0.02 0.01 - 0.03
20–39	240	85.00	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.01 0.01 - 0.01
40–59	281	45.91	—	—	<LOD	<LOD	0.01 <LOD - 0.01	0.01 0.01 - 0.01	0.01 0.01 - 0.02	0.02 0.01 - 0.02
60–79	280	10.71	0.01 0.01 - 0.02	0.01 0.01 - 0.01	<LOD <LOD - 0.01	0.01 0.01 - 0.01	0.01 0.01 - 0.01	0.02 0.01 - 0.02	0.03 0.02 - 0.04	0.04 0.01 - 0.06
Females										
Total, age 20–79	867	52.48	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.01 0.01 - 0.02	0.02 0.01 - 0.02
20–39	286	91.26	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.01 0.01 - 0.01
40–59	315	52.06	—	—	<LOD	<LOD	0.01 <LOD - 0.01	0.01 0.01 - 0.01	0.01 0.01 - 0.02	0.02 0.01 - 0.03
60–79	266	11.28	0.01 0.01 - 0.01	0.01 0.01 - 0.01	<LOD	0.01 0.01 - 0.01	0.01 0.01 - 0.01	0.01 0.01 - 0.02	0.02 0.02 - 0.03	0.02 0.02 - 0.03

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.2.2.3b

cis-Nonachlor (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI*	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	49.10	—	—	<LOD	<LOD	<LOD	1.29 1.07 - 1.52	2.21 1.77 - 2.64	3.13 2.20 - 4.06
20–39	525	88.57	—	—	<LOD	<LOD	<LOD	<LOD	1.09 <LOD - 1.63	1.74 0.97 - 2.50
40–59	596	49.16	—	—	<LOD	<LOD	0.77 <LOD - 1.03	1.23 1.00 - 1.47	2.10 1.49 - 2.71	3.01 1.50 - 4.52
60–79	545	11.01	2.00 1.54 - 2.45	1.52 1.27 - 1.82	<LOD	1.07 0.94 - 1.20	1.52 1.27 - 1.78	2.33 1.85 - 2.81	3.55 2.31 - 4.80	5.50 2.71 - 8.29
Males										
Total, age 20–79	801	45.32	—	—	<LOD	<LOD	<LOD	1.33 1.12 - 1.55	2.21 1.88 - 2.54	3.00 1.86 - 4.14
20–39	240	85.00	—	—	<LOD	<LOD	<LOD	<LOD	1.08 <LOD - 1.56	1.51 0.79 - 2.23
40–59	281	45.91	—	—	<LOD	<LOD	0.77 <LOD - 1.11	1.24 0.99 - 1.50	2.00 1.50 - 2.51	2.59 1.38 - 3.80
60–79	280	10.71	2.27 1.69 - 2.85	1.70 1.39 - 2.09	<LOD <LOD - 1.06	1.15 0.94 - 1.36	1.61 1.28 - 1.95	2.57 1.90 - 3.25	3.89 1.50 - 6.29	6.54 2.81 - 10.26
Females										
Total, age 20–79	865	52.60	—	—	<LOD	<LOD	<LOD	1.26 1.01 - 1.52	2.15 1.49 - 2.80	3.14 2.15 - 4.13
20–39	285	91.58	—	—	<LOD	<LOD	<LOD	<LOD	1.09 <LOD - 1.82	1.79 0.76 - 2.81
40–59	315	52.06	—	—	<LOD	<LOD	0.76 <LOD - 1.01	1.17 0.84 - 1.49	2.10 1.01 - 3.19	3.14 1.35 - 4.93
60–79	265	11.32	1.75 1.36 - 2.13	1.37 1.14 - 1.64	<LOD	0.99 0.78 - 1.19	1.42 1.16 - 1.69	2.14 1.68 - 2.60	3.04 2.00 - 4.08	3.95 2.30 - 5.60

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.2.2.4 *trans*-Nonachlor

Table 8.2.2.4a

***trans*-Nonachlor – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.**

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	6.00	0.05 0.05 - 0.06	0.04 0.03 - 0.04	0.01 <LOD - 0.02	0.02 0.02 - 0.02	0.04 0.03 - 0.04	0.07 0.06 - 0.08	0.11 0.10 - 0.12	0.14 0.12 - 0.16
20–39	526	17.11	0.02 0.02 - 0.03	0.02 0.01 - 0.02	<LOD	0.01 <LOD - 0.02	0.02 0.02 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.05	0.05 0.04 - 0.07
40–59	596	1.68	0.05 0.05 - 0.06	0.04 0.04 - 0.05	0.02 0.02 - 0.02	0.03 0.03 - 0.04	0.05 0.04 - 0.05	0.07 0.06 - 0.07	0.09 0.08 - 0.11	0.11 0.09 - 0.14
60–79	546	0.00	0.10 0.09 - 0.12	0.09 0.08 - 0.10	0.04 0.04 - 0.05	0.06 0.05 - 0.06	0.09 0.07 - 0.10	0.13 0.11 - 0.15	0.16 0.13 - 0.20	0.22 0.14 - 0.30
Males										
Total, age 20–79	801	4.87	0.05 0.05 - 0.06	0.04 0.03 - 0.04	0.01 <LOD - 0.01	0.02 0.02 - 0.02	0.04 0.03 - 0.04	0.07 0.06 - 0.07	0.11 0.10 - 0.12	0.15 0.13 - 0.17
20–39	240	15.00	0.02 0.02 - 0.03	0.02 0.01 - 0.02	<LOD	0.01 <LOD - 0.01	0.02 0.01 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.05	0.05 0.04 - 0.07
40–59	281	1.07	0.05 0.05 - 0.06	0.04 0.04 - 0.05	0.02 0.01 - 0.03	0.03 0.03 - 0.04	0.04 0.04 - 0.05	0.07 0.05 - 0.08	0.09 0.07 - 0.11	0.11 0.10 - 0.12
60–79	280	0.00	0.11 0.09 - 0.13	0.09 0.08 - 0.10	0.05 0.04 - 0.06	0.06 0.05 - 0.06	0.09 0.07 - 0.10	0.13 0.10 - 0.16	0.18 0.14 - 0.22	0.26 0.14 - 0.38
Females										
Total, age 20–79	867	7.04	0.05 0.05 - 0.06	0.04 0.03 - 0.04	<LOD <LOD - 0.01	0.02 0.02 - 0.02	0.04 0.03 - 0.04	0.07 0.06 - 0.08	0.11 0.09 - 0.13	0.14 0.12 - 0.16
20–39	286	18.88	0.02 0.02 - 0.03	0.02 0.01 - 0.02	<LOD	0.01 <LOD - 0.02	0.02 0.01 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.05	0.05 0.02 - 0.08
40–59	315	2.22	0.06 0.05 - 0.07	0.05 0.04 - 0.05	0.02 0.01 - 0.03	0.03 0.03 - 0.04	0.05 0.04 - 0.06	0.07 0.06 - 0.07	0.09 0.07 - 0.12	0.13 0.08 - 0.17
60–79	266	0.00	0.10 0.08 - 0.12	0.08 0.07 - 0.10	0.04 0.03 - 0.05	0.06 0.05 - 0.07	0.08 0.07 - 0.10	0.12 0.10 - 0.14	0.15 0.12 - 0.18	0.20 0.12 - 0.27

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.2.2.4b

trans-Nonachlor (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	6.00	8.51 7.44 - 9.57	5.98 5.29 - 6.77	1.92 <LOD - 2.57	3.53 3.03 - 4.03	6.30 5.41 - 7.20	11.03 9.68 - 12.39	17.59 14.49 - 20.68	22.72 19.44 - 26.01
20–39	525	17.14	4.01 3.34 - 4.69	3.04 2.56 - 3.61	<LOD	2.08 <LOD - 2.73	3.12 2.73 - 3.50	4.61 3.94 - 5.28	7.15 5.26 - 9.04	10.59 7.12 - 14.06
40–59	596	1.68	8.75 7.72 - 9.78	7.31 6.50 - 8.21	3.65 3.22 - 4.09	5.15 4.50 - 5.80	7.45 6.75 - 8.15	10.83 9.27 - 12.40	14.90 12.13 - 17.67	18.93 14.79 - 23.08
60–79	545	0.00	16.07 13.45 - 18.69	13.53 11.70 - 15.65	6.82 5.12 - 8.53	9.68 8.53 - 10.83	13.49 11.43 - 15.54	19.48 16.34 - 22.61	25.85 19.06 - 32.64	33.98 22.18 - 45.77
Males										
Total, age 20–79	801	4.87	8.49 7.50 - 9.48	5.94 5.21 - 6.76	1.92 <LOD - 2.45	3.30 2.80 - 3.81	6.33 5.30 - 7.35	10.94 9.44 - 12.43	17.13 13.79 - 20.47	22.66 18.82 - 26.49
20–39	240	15.00	3.81 3.13 - 4.48	3.01 2.50 - 3.63	<LOD	2.12 <LOD - 2.66	3.06 2.65 - 3.47	4.52 3.68 - 5.36	6.90 4.28 - 9.53	10.83 6.89 - 14.77
40–59	281	1.07	8.57 7.45 - 9.69	7.22 6.14 - 8.50	3.58 2.43 - 4.72	5.20 4.32 - 6.08	7.44 6.43 - 8.45	10.82 8.82 - 12.82	13.66 11.75 - 15.56	17.62 12.70 - 22.55
60–79	280	0.00	17.27 14.64 - 19.91	14.51 12.60 - 16.71	7.97 6.45 - 9.49	9.76 8.83 - 10.69	14.14 11.80 - 16.49	20.77 17.35 - 24.18	31.09 23.56 - 38.63	40.95 29.71 - 52.19
Females										
Total, age 20–79	865	7.05	8.52 7.30 - 9.75	6.03 5.25 - 6.93	<LOD <LOD - 3.00	3.70 2.99 - 4.41	6.23 5.15 - 7.31	11.05 9.52 - 12.58	17.94 14.47 - 21.40	22.72 18.99 - 26.46
20–39	285	18.95	4.23 3.17 - 5.30	3.07 2.45 - 3.85	<LOD	2.07 <LOD - 3.20	3.32 2.65 - 4.00	4.83 3.91 - 5.76	7.13 4.89 - 9.36	9.29 1.96 - 16.62
40–59	315	2.22	8.93 7.63 - 10.23	7.39 6.45 - 8.46	3.68 3.24 - 4.12	5.03 4.27 - 5.79	7.43 6.46 - 8.40	10.82 9.01 - 12.63	15.56 11.23 - 19.89	18.96 12.89 - 25.03
60–79	265	0.00	14.95 12.16 - 17.75	12.68 10.76 - 14.95	6.50 4.74 - 8.26	9.31 7.67 - 10.95	13.21 10.89 - 15.52	18.36 14.95 - 21.77	24.26 18.89 - 29.63	29.49 19.48 - 39.50

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.2.2.5 Oxychlordane

Table 8.2.2.5a

Oxychlordane – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	2.58	0.03 0.03 - 0.04	0.03 0.02 - 0.03	0.01 0.01 - 0.01	0.01 0.01 - 0.02	0.03 0.02 - 0.03	0.04 0.04 - 0.05	0.07 0.06 - 0.08	0.09 0.08 - 0.10
20–39	526	7.03	0.02 0.01 - 0.02	0.01 0.01 - 0.01	0.01 <LOD - 0.01	0.01 0.01 - 0.01	0.01 0.01 - 0.01	0.02 0.02 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.04
40–59	596	0.84	0.04 0.03 - 0.04	0.03 0.03 - 0.03	0.02 0.01 - 0.02	0.02 0.02 - 0.03	0.03 0.03 - 0.03	0.04 0.04 - 0.05	0.06 0.05 - 0.06	0.07 0.06 - 0.08
60–79	546	0.18	0.07 0.06 - 0.07	0.06 0.05 - 0.06	0.03 0.02 - 0.03	0.04 0.04 - 0.04	0.06 0.05 - 0.06	0.08 0.07 - 0.09	0.11 0.09 - 0.12	0.14 0.11 - 0.17
Males										
Total, age 20–79	801	2.00	0.03 0.03 - 0.04	0.02 0.02 - 0.03	0.01 0.01 - 0.01	0.01 0.01 - 0.02	0.03 0.02 - 0.03	0.04 0.04 - 0.04	0.07 0.06 - 0.08	0.08 0.07 - 0.09
20–39	240	6.25	0.02 0.01 - 0.02	0.01 0.01 - 0.01	0.01 <LOD - 0.01	0.01 0.01 - 0.01	0.01 0.01 - 0.02	0.02 0.02 - 0.03	0.03 0.02 - 0.03	0.04 0.03 - 0.04
40–59	281	0.00	0.03 0.03 - 0.04	0.03 0.03 - 0.03	0.01 0.01 - 0.02	0.02 0.02 - 0.02	0.03 0.03 - 0.03	0.04 0.03 - 0.04	0.06 0.05 - 0.06	0.07 0.06 - 0.08
60–79	280	0.36	0.06 0.06 - 0.07	0.05 0.05 - 0.06	0.03 0.02 - 0.03	0.04 0.03 - 0.04	0.06 0.05 - 0.06	0.08 0.07 - 0.09	0.10 0.09 - 0.12	0.13 0.10 - 0.17
Females										
Total, age 20–79	867	3.11	0.04 0.03 - 0.04	0.03 0.02 - 0.03	0.01 0.01 - 0.01	0.02 0.01 - 0.02	0.03 0.03 - 0.03	0.05 0.05 - 0.05	0.07 0.06 - 0.09	0.10 0.08 - 0.11
20–39	286	7.69	0.02 0.01 - 0.02	0.01 0.01 - 0.01	0.01 <LOD - 0.01	0.01 0.01 - 0.01	0.01 0.01 - 0.02	0.02 0.02 - 0.02	0.03 0.02 - 0.03	0.03 0.02 - 0.05
40–59	315	1.59	0.04 0.03 - 0.04	0.03 0.03 - 0.04	0.02 0.01 - 0.02	0.02 0.02 - 0.03	0.03 0.03 - 0.04	0.05 0.04 - 0.05	0.06 0.05 - 0.07	0.08 0.06 - 0.11
60–79	266	0.00	0.07 0.06 - 0.08	0.06 0.05 - 0.07	0.03 0.02 - 0.04	0.04 0.04 - 0.05	0.06 0.05 - 0.07	0.08 0.07 - 0.10	0.11 0.10 - 0.13	0.14 0.08 - 0.19

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.2.2.5b

Oxychlordane (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	2.58	5.60 5.05 - 6.15	4.21 3.80 - 4.67	1.50 1.37 - 1.63	2.53 2.19 - 2.87	4.28 3.82 - 4.74	7.33 6.51 - 8.16	11.02 9.88 - 12.17	14.07 12.30 - 15.84
20–39	525	7.05	2.89 2.58 - 3.20	2.32 2.05 - 2.62	1.09 <LOD - 1.53	1.51 1.36 - 1.65	2.39 2.03 - 2.75	3.55 3.23 - 3.87	5.56 4.36 - 6.77	7.31 5.40 - 9.22
40–59	596	0.84	5.74 5.19 - 6.28	4.98 4.52 - 5.50	2.37 1.83 - 2.91	3.57 3.11 - 4.04	5.14 4.29 - 5.99	7.06 6.18 - 7.95	9.53 8.48 - 10.58	11.14 9.50 - 12.77
60–79	545	0.18	10.18 8.86 - 11.50	8.80 7.79 - 9.93	4.13 3.59 - 4.67	6.33 5.60 - 7.05	8.74 7.49 - 10.00	12.68 11.04 - 14.33	16.90 13.80 - 19.99	20.70 15.80 - 25.60
Males										
Total, age 20–79	801	2.00	5.26 4.71 - 5.81	4.02 3.59 - 4.49	1.62 1.37 - 1.86	2.32 1.99 - 2.66	4.13 3.68 - 4.58	6.69 5.96 - 7.42	10.59 9.42 - 11.76	12.77 10.84 - 14.70
20–39	240	6.25	2.83 2.44 - 3.22	2.32 2.05 - 2.63	1.14 <LOD - 1.46	1.65 1.37 - 1.94	2.26 1.93 - 2.60	3.47 2.88 - 4.06	5.09 3.64 - 6.54	6.92 4.57 - 9.28
40–59	281	0.00	5.29 4.63 - 5.95	4.67 4.09 - 5.34	2.23 1.70 - 2.76	3.25 2.59 - 3.90	4.69 3.72 - 5.66	6.61 5.98 - 7.23	9.16 7.52 - 10.81	11.00 9.89 - 12.11
60–79	280	0.36	9.85 8.61 - 11.09	8.41 7.35 - 9.64	4.06 3.48 - 4.63	5.73 4.75 - 6.71	8.58 6.91 - 10.25	12.20 10.12 - 14.29	16.76 14.26 - 19.26	20.31 16.41 - 24.21
Females										
Total, age 20–79	865	3.12	5.94 5.32 - 6.56	4.41 3.96 - 4.92	1.49 1.26 - 1.69	2.82 2.43 - 3.21	4.61 3.80 - 5.34	7.89 7.11 - 8.67	11.55 9.81 - 13.29	14.62 12.65 - 16.59
20–39	285	7.72	2.95 2.51 - 3.40	2.31 1.95 - 2.74	0.96 <LOD - 1.54	1.49 1.28 - 1.69	2.62 2.01 - 3.23	3.55 3.15 - 3.96	5.62 4.30 - 6.94	7.08 5.26 - 8.89
40–59	315	1.59	6.18 5.52 - 6.84	5.31 4.81 - 5.87	2.68 2.26 - 3.11	3.79 3.36 - 4.23	5.63 4.68 - 6.57	8.01 7.00 - 9.02	10.22 8.07 - 12.37	12.39 9.11 - 15.68
60–79	265	0.00	10.49 8.94 - 12.03	9.17 8.10 - 10.38	4.38 3.16 - 5.60	6.68 6.05 - 7.32	9.03 7.76 - 10.30	12.76 11.22 - 14.30	16.87 12.61 - 21.12	20.94 14.80 - 27.07

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

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8.2.3 Dichlorodiphenyltrichloroethane (DDT) (CASRN 50-29-3)

Dichlorodiphenyltrichloroethane (DDT), also known as 1,1,1-trichloro-2,2-bis(*p*-chlorophenyl)ethane, is an organochlorine insecticide belonging to the class of dichlorodiphenylethanes. In the 1970s and 1980s, many countries, including Canada, banned the use of DDT because of environmental and human health concerns (ATSDR, 2002). The technical grade of DDT, used as an insecticide, was composed of up to fourteen compounds, but was mainly a mixture of three DDT isomers, *p,p'*-DDT (65-80%), *o,p'*-DDT (15-21%), and trace amounts of *o,o'*-DDT (Metcalf, 1995). The term DDT is usually used to refer to *p,p'*-DDT (ATSDR, 2002).

DDT breaks down in the environment to more stable chemical forms, including the following:

- DDE (1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethylene) (CASRN 72-55-9)
- DDD (1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethane) (CASRN 72-54-8)

DDT was first registered for use in Canada in 1946, but was never manufactured in Canada. The import of this insecticide continued until the mid-1970s (CEC, 1997). All existing DDT stocks had to be disposed of by December 31, 1990, in accordance with the *Pest Control Products Act*. This broad-spectrum insecticide became popular due to its effectiveness, persistence, and low cost. DDT was initially used to control vectors of insect-borne human disease, mainly mosquitoes (malaria), midge, and lice (typhus) (ATSDR, 2002). Later, DDT was used to control agricultural pests, and was widely sprayed or dusted over fruit and other food crops. DDT remains in use in some countries, primarily in Africa, to fight malaria (WHO, 2009).

Even though DDT is not currently used in Canada, it remains in the environment due to its persistence. DDT was applied directly to soil and entered surface water bodies due to pest control near water (Environment Canada, 1999). Due to its semi-volatile properties, DDT can reach polar regions by long-range atmospheric transport. The microbial–protozoal–fish–seal–polar bear–human food web serves as a conduit, introducing DDT into the Arctic marine ecosystem and increasing local human exposure (Risebrough et al., 1976; Van Oostdam et al., 2005). In addition, food imported into Canada from other countries that still use DDT may contain residues of DDT or its metabolites, and therefore be a continued source.

The primary route of exposure to DDT for the public is through the ingestion of food—particularly meat, fish, poultry, and dairy products—containing residues of DDT or its degradation products; the highest exposures generally come from fish from the Great Lakes and St. Lawrence River (ATSDR, 2002; Kosatsky et al., 1999). The transport characteristics of DDT make northern populations, especially the Inuit who eat more wild foods (fish, seal, whales, etc.), susceptible to the greatest potential exposure in Canada. As concentrations in the Great Lakes and surrounding rivers decline, DDT intake in fish eaters will decline, which has been seen in surveys of various populations on the St. Lawrence River (Dallaire et al., 2002). Results from the Canadian Total Diet Study (TDS) indicate that average DDT and DDE residue levels in food are generally below 1 µg/kg (Health Canada, 2009). In foods where a Maximum Residue Limit (MRL) has been established (according to the Canadian Food and Drug Regulations) by Health Canada, detectable levels of DDT and DDE were typically less than 1% of the MRL.

DDT can accumulate in humans although it is generally metabolized to DDE, which has become the major residue found in people. Following oral exposure to DDT, absorption occurs mainly through the intestinal lymphatic system, although some absorption into the portal blood also occurs. DDT and its metabolites are distributed via the lymph and blood to all organs and are stored in proportion to the lipid content of each organ. Excretion of DDT in the form of its metabolites (DDE and its conjugates) occurs mainly in the urine, although it may also occur via feces, semen, and breast milk (ATSDR, 2002). DDT and DDE concentrations in human breast milk have been declining in Canada from an average concentration of 134 ng/g whole milk in 1967 to 7.5 ng/g whole milk in 1992 (Craan & Haines, 1998). In specific populations surveyed in Arctic Canada, DDT has been detected in both maternal blood plasma and umbilical cord plasma. Concentrations of total DDT (including metabolites) in maternal blood plasma were highest in the Inuit population of the Baffin region, 2.2 (0.59–6.4) µg/L, compared with 0.96 (0.22–11.3) µg/L in the Caucasian population sampled in the Canadian North (Butler Walker et al., 2003). A study in 1992 of two areas in the Great Lakes region of Ontario, monitored 232 anglers aged 18–64 for levels of *p,p'*-DDE in blood. Among women, fish-eaters had median blood plasma lipid levels of 364.1 µg/kg lipid and non fish-eaters had median levels of 359.8 µg/kg lipid. Among men, fish-eaters had median blood plasma levels of 383.1 µg/kg lipid and non fish-eaters had median levels of 292.8 µg/kg lipid (Kearney et al., 1999).

The best-known effect of DDT (and its metabolites) is the impairment of nerve impulse conduction, which has been observed in both humans and animals, resulting in altered sensations, tremors, and convulsions (ATSDR, 2002). Other notable toxic effects of DDT include the marked alteration of reproduction and development in animals, which is due to the hormone-altering effects of DDT's metabolites, specifically DDE (ATSDR, 2002; CDC, 2005). The International Agency for Research on Cancer (IARC, 1991) has classified DDT, DDE, and DDD as possible human carcinogens (Group 2B), based on sufficient evidence of carcinogenicity in animals. A provisional tolerable daily intake (pTDI) for DDT of 10 µg/kg body weight/day has been established by Health Canada (2007).

DDT is considered to be of concern to the environment and to human health and is managed under Track 1 of the Government of Canada's Toxic Substance Management Policy (Environment Canada, 2006).

DDT is classified as a persistent organic pollutant (POP) by the Stockholm Convention, an international agreement to ban or severely restrict the production and use of POPs (UNEP, 2008).

Blood plasma levels of *p,p'*-DDT and *p,p'*-DDE were measured in a subset of the population aged 20–79 years participating in the Canadian Health Measures Survey and are presented as µg/L plasma and µg/kg lipid (Tables 8.2.3.1a, 8.2.3.1b, 8.2.3.2a, 8.2.3.2b). Participants were selected within the specified age range to be a representative sample of the Canadian population. Finding a measurable amount of DDT or its metabolites in plasma is an indicator of exposure to DDT and does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for plasma levels of *p,p'*-DDT and *p,p'*-DDE in the Canadian population.

8.2.3.1 *p,p'*-Dichlorodiphenyltrichloroethane (*p,p'*-DDT)

Table 8.2.3.1a

p,p'-DDT – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	90.64	—	—	<LOD	<LOD	<LOD	<LOD	<LOD <LOD - 0.11	0.09 <LOD - 0.15
20–39	526	90.87	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.09 <LOD - 0.31
40–59	596	91.95	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.09 0.05 - 0.13
60–79	544	88.97	—	—	<LOD	<LOD	<LOD	<LOD	0.06 <LOD - 0.08	0.09 <LOD - 0.16
Males										
Total, age 20–79	801	91.76	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.08 <LOD - 0.17
20–39	240	92.50	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.08 <LOD - 0.55
40–59	281	92.88	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.08 <LOD - 0.13
60–79	280	90.00	—	—	<LOD	<LOD	<LOD	<LOD	0.05 <LOD - 0.10	0.09 <LOD - 0.17
Females										
Total, age 20–79	865	89.60	—	—	<LOD	<LOD	<LOD	<LOD	0.06 <LOD - 0.08	0.10 0.06 - 0.15
20–39	286	89.51	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.09 <LOD - 0.24
40–59	315	91.11	—	—	<LOD	<LOD	<LOD	<LOD	0.05 <LOD - 0.10	0.10 0.05 - 0.15
60–79	264	87.88	—	—	<LOD	<LOD	<LOD	<LOD	0.06 <LOD - 0.08	0.09 <LOD - 0.15

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.2.3.1b

p,p'-DDT (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1664	90.75	—	—	<LOD	<LOD	<LOD	<LOD	<LOD <LOD - 11.82	15.94 <LOD - 25.80
20–39	525	91.05	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	20.65 <LOD - 55.65
40–59	596	91.95	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	14.38 4.75 - 24.02
60–79	543	89.13	—	—	<LOD	<LOD	<LOD	<LOD	8.99 <LOD - 13.34	12.80 <LOD - 21.13
Males										
Total, age 20–79	801	91.76	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	12.26 <LOD - 28.32
20–39	240	92.50	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	11.47 <LOD - 83.77
40–59	281	92.88	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	11.51 <LOD - 25.17
60–79	280	90.00	—	—	<LOD	<LOD	<LOD	<LOD	6.91 <LOD - 13.63	12.77 <LOD - 21.65
Females										
Total, age 20–79	863	89.80	—	—	<LOD	<LOD	<LOD	<LOD	7.96 <LOD - 12.93	18.18 9.11 - 27.24
20–39	285	89.82	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	20.90 <LOD - 42.67
40–59	315	91.11	—	—	<LOD	<LOD	<LOD	<LOD	6.82 <LOD - 13.71	15.86 5.32 - 26.41
60–79	263	88.21	—	—	<LOD	<LOD	<LOD	<LOD	9.46 <LOD - 13.75	12.91 <LOD - 27.27

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.2.3.2 *p,p'*-Dichlorodiphenyldichloroethylene (*p,p'*-DDE)

Table 8.2.3.2a

p,p'-DDE – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	0.36	2.20 1.19 - 3.21	0.91 0.76 - 1.09	0.26 0.22 - 0.30	0.42 0.37 - 0.46	0.75 0.59 - 0.91	1.77 1.37 - 2.18	4.15 2.82 - 5.48	6.51 4.37 - 8.66
20–39	526	0.57	1.06 0.58 - 1.54	0.53 0.43 - 0.65	0.21 0.18 - 0.24	0.29 0.23 - 0.35	0.43 0.38 - 0.48	0.68 0.46 - 0.91	1.96 0.76 - 3.17	3.78 0.71 - 6.85
40–59	596	0.34	1.77 1.14 - 2.39	1.04 0.84 - 1.28	0.38 0.33 - 0.44	0.54 0.45 - 0.64	0.86 0.64 - 1.08	1.89 1.31 - 2.47	3.89 2.22 - 5.56	5.55 3.80 - 7.29
60–79	546	0.18	5.11 1.17 - 9.06	1.87 1.58 - 2.22	0.55 0.41 - 0.69	0.98 0.79 - 1.16	1.65 1.39 - 1.91	3.51 2.76 - 4.26	7.03 5.32 - 8.73	9.39 7.16 - 11.63
Males										
Total, age 20–79	801	0.25	1.44 1.01 - 1.87	0.81 0.67 - 0.97	0.26 0.21 - 0.30	0.41 0.36 - 0.46	0.67 0.54 - 0.79	1.31 0.98 - 1.64	3.47 1.87 - 5.06	5.55 3.11 - 8.00
20–39	240	0.42	0.93 0.43 - 1.44	0.50 0.40 - 0.63	0.22 0.20 - 0.24	0.29 0.22 - 0.36	0.42 0.37 - 0.47	0.63 0.41 - 0.85	1.45 <LOD - 3.07	3.49 <LOD - 6.92
40–59	281	0.00	1.32 1.00 - 1.65	0.89 0.72 - 1.10	0.37 0.28 - 0.46	0.51 0.40 - 0.61	0.75 0.57 - 0.92	1.30 0.88 - 1.71	2.60 1.07 - 4.14	4.56 2.53 - 6.60
60–79	280	0.36	2.64 1.90 - 3.38	1.63 1.32 - 2.00	0.54 0.43 - 0.64	0.84 0.68 - 0.99	1.36 1.10 - 1.63	3.11 2.09 - 4.13	6.69 4.45 - 8.93	8.27 5.98 - 10.57
Females										
Total, age 20–79	867	0.46	2.97 1.19 - 4.75	1.03 0.84 - 1.26	0.26 0.20 - 0.32	0.44 0.37 - 0.50	0.86 0.59 - 1.12	2.07 1.44 - 2.71	4.97 3.39 - 6.54	7.26 4.14 - 10.39
20–39	286	0.70	1.20 0.58 - 1.82	0.55 0.41 - 0.75	0.20 0.15 - 0.25	0.31 0.22 - 0.39	0.44 0.34 - 0.53	0.75 0.36 - 1.14	2.49 0.76 - 4.23	4.21 0.19 - 8.22
40–59	315	0.63	2.21 1.16 - 3.25	1.21 0.91 - 1.60	0.41 0.37 - 0.45	0.59 0.47 - 0.70	1.06 0.56 - 1.56	2.49 1.29 - 3.70	4.78 2.66 - 6.90	5.95 2.11 - 9.79
60–79	266	0.00	7.40 <LOD - 15.04	2.14 1.65 - 2.76	0.61 0.34 - 0.89	1.15 0.97 - 1.34	1.86 1.52 - 2.20	3.74 2.72 - 4.76	7.49 5.47 - 9.50	10.66 8.26 - 13.05

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.2.3.2b

p,p'-DDE (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	0.36	326.91 210.72 - 443.09	152.05 127.03 - 182.00	45.86 41.12 - 50.61	71.62 63.05 - 80.20	126.78 103.85 - 149.72	284.71 209.05 - 360.37	658.36 416.92 - 899.80	1077.47 687.77 - 1467.17
20–39	525	0.57	198.69 115.13 - 282.26	94.68 77.00 - 116.43	36.79 30.34 - 43.23	49.30 41.98 - 56.63	74.96 63.65 - 86.27	129.29 86.78 - 171.81	365.35 109.07 - 621.63	819.77 238.73 - 1400.82
40–59	596	0.34	282.00 188.51 - 375.49	168.13 137.66 - 205.35	61.29 51.68 - 70.90	88.95 76.54 - 101.36	139.67 103.07 - 176.26	297.23 197.45 - 397.01	627.71 363.50 - 891.92	890.06 449.65 - 1330.47
60–79	545	0.18	645.16 279.72 - 1010.60	291.27 247.49 - 342.80	83.13 60.20 - 106.05	150.85 127.26 - 174.43	269.54 238.62 - 300.45	537.80 448.81 - 626.79	997.48 770.23 - 1224.74	1546.62 958.58 - 2134.65
Males										
Total, age 20–79	801	0.25	235.39 168.99 - 301.80	134.43 110.82 - 163.07	45.41 39.74 - 51.09	69.34 57.79 - 80.90	110.80 87.26 - 134.35	215.48 162.96 - 268.00	534.27 273.44 - 795.09	896.88 531.58 - 1262.18
20–39	240	0.42	162.47 74.77 - 250.17	88.12 69.43 - 111.85	37.68 30.33 - 45.03	47.75 37.78 - 57.73	72.36 57.14 - 87.57	113.06 59.13 - 166.99	244.65 <LOD - 503.34	506.52 <LOD - 1186.37
40–59	281	0.00	221.13 167.35 - 274.91	145.02 117.13 - 179.54	56.28 47.44 - 65.11	82.88 70.27 - 95.49	122.82 95.69 - 149.95	208.60 146.81 - 270.40	499.91 237.34 - 762.48	730.42 482.63 - 978.21
60–79	280	0.36	404.07 315.54 - 492.59	258.10 212.66 - 313.24	74.87 53.59 - 96.15	132.55 109.02 - 156.07	228.17 181.23 - 275.12	509.76 392.26 - 627.26	927.87 664.53 - 1191.22	1137.21 787.55 - 1486.87
Females										
Total, age 20–79	865	0.46	418.77 235.04 - 602.49	172.07 140.77 - 210.32	46.36 39.02 - 53.70	75.15 63.82 - 86.48	142.03 103.11 - 180.95	372.05 261.50 - 482.61	779.92 504.71 - 1055.14	1200.67 612.08 - 1789.27
20–39	285	0.70	236.97 112.80 - 361.14	102.15 74.69 - 139.71	35.94 27.12 - 44.76	49.64 40.59 - 58.68	78.19 59.64 - 96.74	140.55 76.90 - 204.20	478.63 74.22 - 883.03	832.19 <LOD - 2095.74
40–59	315	0.63	342.71 188.31 - 497.10	194.85 150.23 - 252.71	65.93 58.22 - 73.64	101.67 87.43 - 115.92	172.08 103.17 - 240.99	390.31 240.33 - 540.30	721.80 292.51 - 1151.08	1191.24 563.89 - 1818.58
60–79	265	0.00	868.71 <LOD - 1563.81	325.83 256.81 - 413.40	89.85 49.82 - 129.88	169.17 131.22 - 207.11	283.59 239.64 - 327.54	575.28 448.22 - 702.33	1124.18 579.05 - 1669.32	1944.05 1251.32 - 2636.78

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

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8.2.4 Hexachlorobenzene (CASRN 118-74-1)

Hexachlorobenzene (HCB), also known as pentachlorophenyl chloride, is a synthetic organochlorine compound with the molecular formula C_6Cl_6. HCB does not occur naturally in the environment.

HCB was previously used in several products, including pesticides, fireworks, ammunition, synthetic rubber, wood preservative, and dielectric fluids, and as an aluminium fluxing agent (ATSDR, 2002; Aulagnier & Poissant, 2005; CCME, 1999). Its primary application in Canada was as a fungicide treatment for grain seeds, which began in the 1940s and continued through until the 1970s (ATSDR, 2002). HCB has not been used commercially in Canada since 1976 (Environment Canada, 2005), is no longer used commercially in the United States, and has not been produced in North America since the late 1970s (ATSDR, 2002).

HCB previously entered the environment through application to crops and disposal of industrial and commercial waste (ATSDR, 2002). Today, releases of HCB to the environment can occur from the manufacture and use of chlorinated solvents and pesticides that contain HCB impurities, long-range transport and deposition from contaminated areas, and industrial and incineration emissions that produce HCB through incomplete combustion (Environment Canada & Health Canada, 1993). Once in the environment, HCB is persistent and very resistant to biotic and abiotic degradation; as a result, it is found in a wide range of environmental media in Canada. HCB can bioaccumulate in fatty tissues in animals and humans, and metabolic breakdown is limited (WHO, 2004).

Exposure of the general population to HCB is primarily through the ingestion of food grown in soil contaminated with HCB or the ingestion of animal tissue that has accumulated HCB, especially foods with high lipid content. When HCB was measured in Canadian foods in 1998 as part of the Canadian Total Diet Study, concentrations ranged from 0.29 parts per billion (ppb) in fish to 1.00 ppb in butter (Health Canada, 1998). Exposure may also occur through inhalation or dermal contact, although these exposures tend to be much lower than ingestion exposures (ATSDR, 2002; Environment Canada & Health Canada, 1993).

Tissue distribution of HCB appears to be governed by its lipophilicity and the relative fat content of the various tissues (Lu et al., 2006). In general, fecal excretion of the parent compound is the major pathway of elimination of HCB, with minor proportions excreted as metabolites in urine and feces (Koss & Koransky, 1975). Liver toxicity in rats is the most sensitive target organ toxicity observed in a number of studies (Koss & Koransky, 1975; Kuiper-Goodman et al., 1977; Yang et al., 1978). HCB has been estimated to have a whole body half-life of six years (To-Figueras et al., 1997).

Animal tests have demonstrated that long-term ingestion of large amounts of HCB can result in damage to the liver, kidney, and thyroid (including tumours in each of these organs), and damage to the nervous system (ATSDR, 2002). HCB was a causative agent in a poisoning incident in Turkey, when HCB-treated seeds intended for use in agriculture were instead diverted for human consumption over a period of several years. In this incident, exposure to HCB was related to occurrence of liver disease, higher death rates in young children, as well as skin lesions, hyperpigmentation, hirsutism, colic, weakness, enlarged thyroid, and porphyrinuria (ATSDR, 2002; IPCS, 1996).

Health Canada has classified HCB as a probable human carcinogen (Group II), based on inadequate data on humans but sufficient evidence of carcinogenicity in several rodent species exposed to high doses over their lifetimes (Environment Canada & Health Canada, 1993). A provisional tolerable daily intake (pTDI) for HCB of 0.27 µg/kg body weight/day has been adopted by Health Canada (2007).

Environment Canada and Health Canada concluded that HCB is of concern to the environment and to human health (Environment Canada & Health Canada, 1993). HCB is designated as a Track 1 substance under the Government of Canada's Toxic Substance Management Policy with the objective of virtual elimination (i.e., no measureable releases) from the environment (Environment Canada, 2006). HCB is classified as a persistent organic pollutant (POP) by the Stockholm Convention, an international agreement to ban or severely restrict the production and use of POPs (UNEP, 2008).

HCB concentrations in human breast milk have been declining in southern Canada, with an average concentration in human milk of 2 μg/L in 1975, declining to 0.44 μg/L in 1992 (Craan & Haines, 1998). In specific populations surveyed in Arctic Canada, HCB was detected in both maternal blood plasma and umbilical cord plasma 1995–1999. Concentrations of HCB in maternal blood plasma were highest in the Inuit population of Northwest Territories and Nunavut, geometric mean 0.47 (0.05–4.51) μg/L, compared to 0.12 (0.04–0.61) μg/L in the Caucasian population sampled in these territories (Butler Walker et al., 2003). The Inuit in the Canadian Arctic have higher body burdens due to the bioaccumulation of HCB in their traditional marine mammal diet.

Blood plasma levels of HCB were measured in a subset of the population aged 20–79 participating in the Canadian Health Measures Survey and are presented as μg/L plasma and μg/kg lipid (Tables 8.2.4a, 8.2.4b). Participants were selected within the specified age range to be a representative sample of the Canadian population. Finding a measurable amount of HCB in plasma is an indicator of exposure to HCB and does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for blood plasma levels of HCB in the Canadian population.

Table 8.2.4a

Hexachlorobenzene – Arithmetic and geometric means, and selected percentiles of plasma concentrations (μg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	24.70	0.07 0.06 - 0.09	0.05 0.05 - 0.06	<LOD	<LOD	0.06 0.05 - 0.06	0.09 0.07 - 0.10	0.13 0.11 - 0.15	0.17 0.14 - 0.20
20–39	526	47.91	—	—	<LOD	<LOD	0.04 <LOD - 0.05	0.06 0.05 - 0.07	0.08 0.06 - 0.10	0.13 0.07 - 0.20
40–59	596	18.79	0.07 0.06 - 0.08	0.06 0.05 - 0.07	<LOD	0.05 0.04 - 0.05	0.06 0.06 - 0.07	0.09 0.07 - 0.10	0.12 0.10 - 0.15	0.16 0.13 - 0.19
60–79	546	8.79	0.12 0.09 - 0.15	0.08 0.07 - 0.10	0.04 <LOD - 0.05	0.06 0.05 - 0.07	0.09 0.08 - 0.10	0.12 0.11 - 0.14	0.17 0.13 - 0.22	0.22 0.17 - 0.28
Males										
Total, age 20–79	801	23.85	0.06 0.06 - 0.07	0.05 0.05 - 0.06	<LOD	<LOD	0.06 0.05 - 0.06	0.08 0.07 - 0.09	0.11 0.09 - 0.13	0.14 0.11 - 0.17
20–39	240	43.75	—	—	<LOD	<LOD	0.04 <LOD - 0.05	0.06 0.05 - 0.07	0.08 0.06 - 0.10	0.10 0.05 - 0.16
40–59	281	18.15	0.07 0.06 - 0.08	0.06 0.05 - 0.06	<LOD	0.04 <LOD - 0.05	0.06 0.06 - 0.07	0.08 0.07 - 0.09	0.11 0.09 - 0.13	0.14 0.11 - 0.16
60–79	280	12.50	0.08 0.07 - 0.10	0.07 0.06 - 0.08	<LOD	0.05 0.04 - 0.06	0.07 0.06 - 0.08	0.10 0.08 - 0.12	0.13 0.09 - 0.17	0.17 0.09 - 0.25
Females										
Total, age 20–79	867	25.49	0.09 0.07 - 0.10	0.06 0.05 - 0.07	<LOD	0.04 <LOD - 0.05	0.06 0.05 - 0.07	0.10 0.08 - 0.11	0.15 0.12 - 0.18	0.19 0.14 - 0.24
20–39	286	51.40	—	—	<LOD	<LOD	0.04 <LOD - 0.05	0.06 0.05 - 0.07	0.08 <LOD - 0.12	0.15 0.06 - 0.25
40–59	315	19.37	0.08 0.06 - 0.09	0.06 0.05 - 0.07	<LOD	0.05 0.04 - 0.05	0.07 0.06 - 0.07	0.09 0.07 - 0.11	0.15 0.10 - 0.19	0.16 0.13 - 0.19
60–79	266	4.89	0.15 0.10 - 0.20	0.10 0.09 - 0.12	0.05 <LOD - 0.07	0.07 0.06 - 0.09	0.10 0.09 - 0.12	0.14 0.11 - 0.16	0.20 0.16 - 0.25	0.26 0.09 - 0.44

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.2.4b

Hexachlorobenzene (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (μg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	24.73	12.14 10.04 - 14.25	9.09 8.02 - 10.30	<LOD	<LOD	9.31 8.35 - 10.27	13.87 11.94 - 15.80	21.01 16.98 - 25.05	26.61 20.14 - 33.09
20–39	525	48.00	—	—	<LOD	<LOD	7.07 <LOD - 8.79	9.98 8.63 - 11.34	15.31 11.23 - 19.38	22.95 10.44 - 35.46
40–59	596	18.79	11.72 9.91 - 13.53	9.71 8.51 - 11.08	<LOD	7.14 6.18 - 8.10	9.93 8.83 - 11.04	14.20 11.81 - 16.60	20.99 16.01 - 25.97	24.67 21.83 - 27.50
60–79	545	8.81	17.84 13.22 - 22.47	13.12 11.28 - 15.25	6.05 <LOD - 8.52	9.18 7.67 - 10.70	13.30 12.08 - 14.51	18.75 15.72 - 21.77	26.38 18.15 - 34.61	36.14 22.75 - 49.52
Males										
Total, age 20–79	801	23.85	10.49 9.11 - 11.87	8.46 7.65 - 9.35	<LOD	<LOD	8.78 8.04 - 9.52	13.15 11.53 - 14.77	17.70 13.79 - 21.62	22.90 19.67 - 26.12
20–39	240	43.75	—	—	<LOD	<LOD	7.00 <LOD - 8.69	9.89 8.04 - 11.75	14.75 11.21 - 18.29	17.11 10.16 - 24.05
40–59	281	18.15	11.19 9.58 - 12.80	9.23 8.20 - 10.37	<LOD	6.70 <LOD - 7.66	9.66 8.38 - 10.94	13.46 12.16 - 14.75	18.15 12.75 - 23.55	22.80 19.89 - 25.71
60–79	280	12.50	13.08 10.33 - 15.83	10.76 9.16 - 12.64	<LOD	7.83 6.63 - 9.03	10.76 8.74 - 12.78	15.41 12.67 - 18.15	21.75 14.91 - 28.60	25.94 5.23 - 46.64
Females										
Total, age 20–79	865	25.55	13.80 10.75 - 16.85	9.76 8.36 - 11.40	<LOD	5.84 <LOD - 7.86	9.94 8.86 - 11.01	15.43 12.75 - 18.12	23.15 18.24 - 28.05	31.32 21.18 - 41.46
20–39	285	51.58	—	—	<LOD	<LOD	6.48 <LOD - 8.58	10.09 8.67 - 11.50	15.34 <LOD - 25.35	34.13 5.10 - 63.16
40–59	315	19.37	12.26 9.93 - 14.58	10.22 8.62 - 12.10	<LOD	7.88 6.79 - 8.96	10.11 8.78 - 11.45	15.40 11.30 - 19.50	22.05 16.73 - 27.37	25.78 22.40 - 29.16
60–79	265	4.91	22.27 15.07 - 29.46	15.76 13.29 - 18.69	7.77 <LOD - 10.60	11.66 10.30 - 13.01	15.49 13.89 - 17.10	20.42 17.13 - 23.72	31.59 23.06 - 40.12	39.73 11.21 - 68.26

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

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8.2.5 Hexachlorocyclohexane

Hexachlorocyclohexane (HCH), formerly known as benzenehexachloride (BHC), has the chemical formula $C_6H_6Cl_6$. It is an organochlorine compound with eight isomers (alpha [CASRN 319-84-6], beta [CASRN 319-85-7], gamma [CASRN 58-89-9], etc.) that are distinguished by the position of chlorine atoms on a six-carbon ring. HCH is a synthetic chemical with no natural sources. HCH was originally produced and applied as a pesticide in the form of a technical mixture of several isomers. More recently, this technical mixture was processed so that the gamma-hexachlorocyclohexane (γ-HCH) isomer, which has most of the pesticidal properties of the HCH isomers, could be applied as a pure product. γ-HCH is more commonly known as lindane (ATSDR, 2005; Health Canada, 2009a).

The sale and use of organochlorine pesticides, including lindane, is regulated in Canada by the Pest Management Regulatory Agency (PMRA). In 2002, PMRA completed a review of lindane and product registrations were phased out by December 31, 2004. No lindane products are registered under the *Pest Control Products Act*. However, lindane (γ-HCH) remains in use as a therapeutic product under the *Food and Drugs Act* to control lice and scabies (mites) outbreaks in humans (Health Canada, 1989a, 1989b). This last Canadian use is expected to cease by August 2015, as required by an amendment to the Stockholm Convention which Canada has indicated it plans to ratify (Foreign Affairs and International Trade Canada, 2010).

HCH was previously released into the environment by agricultural activities throughout Canada, with the highest levels of use occurring in the Prairies on canola crops. The atmospheric transport of HCH isomers around the globe has also been well documented (Wania et al., 1999). Since only lindane (γ-HCH) is still used in Canada, it would not be unexpected to find low levels of this isomer in the environment. However, due to extensive global use of technical HCH, and the persistence of β-HCH and α-HCH contained therein, these two isomers are also found in the environment (ATSDR, 2005).

The public may be exposed to HCH isomers primarily by ingestion of food with HCH residues, but other pathways such as ingestion of drinking water and inhalation of ambient air are also possible. Short-term exposure to γ-HCH also occurs through use of prescription medication for scabies or head lice (ATSDR, 2005).

HCH isomers have been detected in a range of foods including dairy products, meat, fish, poultry, fruits, vegetables, peanuts, seeds, sugars, oils, and fats (Gartrell et al., 1986; Health Canada, 2006). Results from the Canadian Total Diet Study (TDS) indicate that average HCH residue levels in food are generally below 1 μg/kg, although in some years, residue levels of up to 8 μg/kg were found in peanuts, peanut butter, and chocolate bars (Health Canada, 2009b). In foods where a Maximum Residue Limit (MRL) has been established (according to the Canadian Food and Drug Regulations) by Health Canada, detectable levels of HCH isomers were typically less than 1% of the MRL.

HCH is readily absorbed when ingested by humans. It is metabolized in the liver prior to excretion in urine; since many of these metabolites are not specific to HCH, it is difficult to evaluate exposure using urine samples. Blood samples have been used to evaluate HCH exposure; β-HCH accumulates in fatty tissues and has a blood elimination half-life of approximately seven years, whereas γ-HCH has a much shorter blood elimination half-life of only 20 hours (CDC, 2005; ATSDR, 2005). β-HCH measurements in human breast milk in Canada decreased from 8 ng/g whole milk in 1982 to 0.71 ng/g whole milk in 1992 (Craan & Haines, 1998). In specific populations surveyed in the Canadian Arctic, β-HCH was detected in both maternal blood plasma and umbilical cord plasma 1995–1999. Concentrations of β-HCH in maternal blood plasma were 0.09 (ND–0.55) μg/L in the Caucasian and Inuit mothers sampled in the Canadian North, while the geometric mean in other non-aboriginal mothers from the Northwest Territories was 0.48 (0.04–39) μg/L (Butler Walker et al., 2003). The higher levels observed in other non-aboriginal mothers in the Canadian Arctic may be due to exposure to β-HCH from their countries of birth in Africa or Asia, or from foods imported from these regions.

At high doses, HCH can affect the nervous system, and symptoms of exposure to HCH may include malaise, vomiting, tremors, apprehension, confusion, loss of sleep, impaired memory, and loss of libido (ATSDR, 2005). Lindane and other HCH isomers can also have effects on the liver, kidneys, and endocrine system, and may have immunotoxic potential (Health Canada, 2009; ATSDR, 2005). The International Agency for Research on Cancer (IARC, 1987) has classified HCH as a possible human carcinogen (Group 2B), based on inadequate human data but sufficient evidence in animals for technical- and α-HCH, and limited evidence for β- and γ-HCH. A provisional tolerable daily intake (pTDI) for total HCH of 0.3 mg/kg body weight per day has been adopted by Health Canada (2007).

Blood plasma levels of two HCH isomers (β and γ) were measured in a subset of the population aged 20–79 years participating in the Canadian Health Measures Survey and are presented as µg/L plasma and µg/kg lipid (Tables 8.2.5.1a – 8.2.5.2b). Participants were selected within the specified age range to be a representative sample of the Canadian population. Finding a measurable amount of HCH in plasma is an indicator of exposure to HCH and does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for blood plasma levels of HCH in the Canadian population.

8.2.5.1 ß-Hexachlorocyclohexane

Table 8.2.5.1a

ß-Hexachlorocyclohexane – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	6.95	0.23 0.08 - 0.39	0.04 0.03 - 0.05	<LOD <LOD - 0.01	0.02 0.02 - 0.02	0.03 0.03 - 0.04	0.06 0.04 - 0.08	0.17 <LOD - 0.40	0.54 0.07 - 1.01
20–39	526	18.82	0.14 0.02 - 0.26	0.02 0.02 - 0.03	<LOD	0.01 <LOD - 0.01	0.02 0.01 - 0.02	0.03 0.02 - 0.04	0.11 <LOD - 0.35	0.47 <LOD - 0.94
40–59	596	2.68	0.25 <LOD - 0.49	0.05 0.03 - 0.06	0.01 0.01 - 0.02	0.02 0.02 - 0.03	0.04 0.03 - 0.04	0.06 0.04 - 0.09	0.18 <LOD - 0.52	0.55 <LOD - 1.70
60–79	546	0.18	0.36 0.09 - 0.63	0.07 0.06 - 0.09	0.03 0.02 - 0.03	0.04 0.03 - 0.04	0.06 0.05 - 0.07	0.10 0.07 - 0.14	0.21 0.07 - 0.36	0.43 0.07 - 0.79
Males										
Total, age 20–79	801	8.24	0.13 <LOD - 0.25	0.03 0.02 - 0.04	<LOD	0.02 0.01 - 0.02	0.03 0.02 - 0.03	0.05 0.03 - 0.07	0.13 <LOD - 0.33	0.40 0.08 - 0.72
20–39	240	23.33	0.12 <LOD - 0.27	0.02 0.01 - 0.03	<LOD	<LOD	0.02 0.01 - 0.02	0.03 0.02 - 0.03	0.05 <LOD - 0.22	0.38 <LOD - 0.90
40–59	281	3.20	0.10 0.04 - 0.15	0.04 0.03 - 0.06	0.01 0.01 - 0.02	0.02 0.02 - 0.03	0.03 0.02 - 0.04	0.06 0.03 - 0.08	0.13 <LOD - 0.36	0.36 0.04 - 0.68
60–79	280	0.36	0.22 <LOD - 0.50	0.06 0.05 - 0.08	0.02 0.02 - 0.02	0.03 0.03 - 0.04	0.05 0.04 - 0.06	0.08 0.03 - 0.14	0.21 0.01 - 0.42	0.39 0.03 - 0.76
Females										
Total, age 20–79	867	5.77	0.34 0.11 - 0.57	0.04 0.03 - 0.06	0.01 <LOD - 0.01	0.02 0.02 - 0.02	0.04 0.03 - 0.04	0.07 0.05 - 0.10	0.24 <LOD - 0.57	0.82 <LOD - 2.35
20–39	286	15.03	0.17 0.03 - 0.30	0.03 0.02 - 0.04	<LOD	0.01 0.01 - 0.01	0.02 0.02 - 0.02	0.03 <LOD - 0.06	0.33 <LOD - 0.77	0.81 <LOD - 1.76
40–59	315	2.22	0.40 <LOD - 0.87	0.05 0.03 - 0.08	0.02 0.01 - 0.02	0.02 0.02 - 0.03	0.04 0.03 - 0.04	0.07 0.01 - 0.12	0.19 <LOD - 1.29	1.31 <LOD - 6.67
60–79	266	0.00	0.50 0.06 - 0.94	0.09 0.07 - 0.11	0.03 0.02 - 0.04	0.05 0.04 - 0.06	0.07 0.05 - 0.08	0.11 0.09 - 0.14	0.19 0.01 - 0.36	0.55 <LOD - 1.10

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.2.5.1b

ß-Hexachlorocyclohexane (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	6.96	36.52 11.12 - 61.91	6.39 4.77 - 8.57	<LOD <LOD - 2.32	2.95 2.62 - 3.28	5.19 4.25 - 6.13	10.40 6.96 - 13.83	28.10 <LOD - 62.58	90.01 9.22 - 170.79
20–39	525	18.86	26.18 5.64 - 46.73	3.95 2.88 - 5.40	<LOD	1.94 <LOD - 2.38	2.98 2.54 - 3.42	5.32 3.75 - 6.90	22.30 <LOD - 60.04	98.01 <LOD - 190.01
40–59	596	2.68	42.83 <LOD - 87.76	7.38 5.22 - 10.45	2.57 2.12 - 3.03	3.66 2.99 - 4.33	5.72 4.60 - 6.83	9.87 6.23 - 13.51	26.48 <LOD - 73.33	87.76 <LOD - 274.84
60–79	545	0.18	42.57 17.87 - 67.27	11.44 9.07 - 14.44	4.12 3.49 - 4.75	6.35 5.58 - 7.12	9.83 8.14 - 11.53	15.79 10.76 - 20.82	30.82 7.46 - 54.17	62.47 <LOD - 125.95
Males										
Total, age 20–79	801	8.24	19.55 <LOD - 37.35	5.45 4.06 - 7.32	<LOD	2.81 2.32 - 3.31	4.72 3.90 - 5.54	8.39 5.30 - 11.48	21.40 <LOD - 53.20	66.73 14.42 - 119.05
20–39	240	23.33	18.98 <LOD - 43.26	3.26 2.38 - 4.45	<LOD	<LOD	2.90 2.10 - 3.69	4.86 3.53 - 6.20	8.99 <LOD - 37.74	62.96 <LOD - 141.56
40–59	281	3.20	15.91 7.08 - 24.73	6.60 4.67 - 9.31	2.38 1.83 - 2.93	3.37 2.79 - 3.94	5.21 3.98 - 6.45	8.53 3.91 - 13.16	21.95 <LOD - 58.51	73.29 10.95 - 135.63
60–79	280	0.36	28.10 <LOD - 59.94	9.85 7.25 - 13.38	3.80 3.36 - 4.25	5.08 4.18 - 5.98	8.37 6.41 - 10.33	15.04 6.76 - 23.31	40.09 13.71 - 66.46	49.83 8.21 - 91.46
Females										
Total, age 20–79	865	5.78	53.54 13.45 - 93.64	7.51 5.40 - 10.43	2.09 <LOD - 2.36	3.05 2.69 - 3.42	5.82 4.72 - 6.92	11.59 8.34 - 14.84	34.43 <LOD - 91.27	196.94 <LOD - 467.34
20–39	285	15.09	33.80 5.92 - 61.68	4.83 3.09 - 7.55	<LOD	2.15 1.85 - 2.46	3.01 2.63 - 3.40	5.76 <LOD - 11.54	55.97 <LOD - 141.80	218.04 <LOD - 479.91
40–59	315	2.22	69.67 <LOD - 156.43	8.26 5.27 - 12.93	2.63 2.13 - 3.14	3.97 3.25 - 4.68	6.14 4.96 - 7.32	10.61 2.85 - 18.36	34.50 <LOD - 199.50	189.23 <LOD - 1355.25
60–79	265	0.00	55.98 21.57 - 90.40	13.15 10.56 - 16.38	5.43 4.03 - 6.83	7.19 5.92 - 8.46	10.72 9.00 - 12.44	17.49 12.85 - 22.14	27.68 <LOD - 67.59	96.42 <LOD - 238.54

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.2.5.2 γ-Hexachlorocyclohexane (Lindane)

Table 8.2.5.2a

γ-Hexachlorocyclohexane (Lindane) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (μg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95% CI	G.M. 95% CI	10th 95% CI	25th 95% CI	50th 95% CI	75th 95% CI	90th 95% CI	95th 95% CI
Total, age 20–79	1665	99.34	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	526	99.62	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	596	99.16	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	543	99.26	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	801	99.25	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	99.58	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	99.64	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	98.57	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	864	99.42	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	286	99.65	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	315	98.73	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	263	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.2.5.2b

γ-Hexachlorocyclohexane (Lindane) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (μg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1663	99.46	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	525	99.81	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	596	99.16	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	542	99.45	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	801	99.25	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	99.58	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	99.64	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	98.57	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	862	99.65	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	285	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	315	98.73	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	262	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

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8.2.6 Mirex (CASRN 2385-85-5)

Mirex is a synthetic organochlorine compound with the systematic name 1,1a,2,2,3,3a,4,5,5,5a,5b,6-dodecachlorooctahydro-1,3,4-metheno-1H-cyclobuta[cd]-pentalene and the chemical formula $C_{10}Cl_{12}$. Technical grade mirex is a white crystalline solid, containing 95.18% mirex and a small amount of chlordecone. Mirex is also known under the trade names CG-1273, dechlorane, HRS1276b, ENT 25719, ferriamicide, and NCI-C06428 (ATSDR, 1995; US EPA, 1992). Mirex is commonly encountered with photomirex, or 8-monohydromirex (CASRN 39801-14-4), which is produced by the environmental degradation of mirex (ATSDR, 1995).

Mirex is not naturally present in the environment, and the only sources are anthropogenic. Mirex was primarily marketed as a flame retardant in the United States and was added to plastics, rubber, paint, paper, and electrical goods from 1952 to 1972. Mirex was also previously used as an insecticide, primarily against ant and termite species in the United States, South America, and South Africa (ATSDR, 1995); however, mirex was never registered for use as a pesticide in Canada (Environment Canada, 1997).

Mirex is no longer registered for use in Canada (Health Canada, 2009). Mirex is classified as a persistent organic pollutant (POP) by the Stockholm Convention (UNEP, 2005).

While mirex was not used as a pesticide in Canada, it has entered the Canadian environment via long-range atmospheric transport, water and sediments from manufacturing near the Niagara and Oswego rivers in the United States, and products that contained mirex as a flame retardant prior to 1978 (Environment Canada, 1997). Due to the bans on mirex in Canada and the

United States, environmental concentrations have been decreasing since the 1980s (ATSDR, 1995).

The primary method of exposure of the public to mirex is through the ingestion of food. In the past, the highest concentrations of mirex were found in fish from the Great Lakes region (ATSDR, 1995). Additionally, First Nations peoples and individuals living in Arctic communities who consume large amounts of fish or mammal fat may be exposed to greater than normal amounts of mirex, due to bioaccumulation in marine and terrestrial food chains (ATSDR, 1995).

Mirex was not an analyte in past or present Canadian or United States Total Diet Studies, and there are limited data available on the concentrations of mirex in commercial food products. Samples of fat from domestic farm animals in Ontario did not have detectable levels of mirex (Ritter et al., 1995); the detection limit was not provided. Samples of Ooligan fish, a food source for indigenous populations on the coast of British Columbia, had average mirex and photomirex concentrations of <0.05–0.3 ng/g in three different rivers (Chan et al., 1996).

Mirex is not commonly detected in water as it is practically insoluble (ATSDR, 1995; Ritter et al., 1995). Mirex was detected in five of 1147 drinking water samples from Ontario in 1987, at a maximum concentration of 5 ng/L (0.005 ppb) (ATSDR, 1995).

Mirex is not readily metabolized and bioaccumulates in fat tissues due to its high lipophilicity, especially in aquatic animals (ATSDR, 1995). The mirex concentrations in salmon from Lake Ontario decreased by 90–95% from 1976 to 2003 (French et al., 2006); however, beluga whales tested in the St. Lawrence estuary from 1987 to 2002 showed no decrease in mirex concentrations (Lebeuf et al., 2007).

Once mirex enters the body, it is mostly excreted unchanged through feces within 48 hours, with the remainder accumulating in fat tissue as it cannot be metabolized. Mirex is commonly measured in human blood serum, as well as breast milk and adipose tissue. Detection frequencies have increased since the 1980s; however, this is generally due to improved analytical detection limits (ATSDR, 1995). In a survey of human adipose tissue from southwestern Ontario from 1976 to 1979, mirex was detected with 32.8% frequency at a mean concentration of <0.01 ppm; in a similar survey in 1980–1981, mirex was detected with a 64.8% frequency and a mean concentration of 0.04 ppm, and in 1983–1984, the frequency of detection was 6.2% and the mean mirex concentration was 0.06 ppm (ATSDR, 1995). Mirex was detected in 62% of breast-milk samples from women across Canada in a 1993 study with a mean concentration of 0.14 ppb (ATSDR, 1995). Mirex was detected in 37.2% of blood samples with a detection limit of 0.015 µg/L in a 2000–2004 case-control study in British Columbia (Spinelli et al., 2007). In a pilot study carried out in 1992 in two regions of the Great Lakes area of Ontario, 232 anglers were assessed for the levels of mirex in blood plasma. Geometric mean and maximum concentrations of mirex were 7.63 µg/kg plasma lipid and 146.4 µg/kg plasma lipid, respectively (Kearney et al., 1995).

Chronic oral exposure to mirex has been related to liver effects in occupationally exposed individuals (ATSDR, 1995). In laboratory animals, chronic oral exposure to mirex produces evidence of cardiovascular effects, potential neurotoxicity, adverse reproductive and developmental effects, mild hepatological effects, gastrointestinal effects (diarrhea), adaptive and toxic hepatic effects, and endocrine effects (thyroid and adrenal toxicity) (ATSDR, 1995; Ritter et al., 1995). The primary target organs for oral mirex toxicity, as determined by animal studies, are the liver, kidney, eyes, and thyroid gland (ATSDR, 1995).

A provisional tolerable daily intake (pTDI) for mirex of 0.07 µg/kg body weight per day has been adopted by Health Canada (2007). The International Agency for Research on Cancer (IARC, 1979) classified mirex as a possible human carcinogen (Group 2B) based on the absence of adequate human data and sufficient evidence of carcinogenicity in animals. Recent studies in humans have associated mirex with increased risks of breast cancer (Salehi et al., 2008), and T-cell lymphoma (Spinelli et al., 2007).

Blood plasma levels of mirex were measured in a subset of the population aged 20–79 years participating in the Canadian Health Measures Survey and are presented as µg/L plasma and µg/kg lipid (Tables 8.2.6a, 8.2.6b). Participants were selected within the specified age range to be a representative sample of the Canadian population. Finding a measurable amount of mirex in blood plasma is an indicator of exposure to mirex and does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for blood plasma levels of mirex in the Canadian population.

Table 8.2.6a

Mirex – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	47.36	—	—	<LOD	<LOD	<LOD	0.02 0.02 - 0.02	0.04 0.03 - 0.04	0.05 0.04 - 0.06
20–39	526	86.50	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.02	0.03 <LOD - 0.05
40–59	596	38.93	0.02 0.01 - 0.02	0.01 0.01 - 0.01	<LOD	<LOD	0.01 0.01 - 0.01	0.02 0.02 - 0.03	0.04 0.03 - 0.04	0.05 0.04 - 0.06
60–79	546	18.86	0.03 0.03 - 0.04	0.02 0.02 - 0.02	<LOD	0.01 <LOD - 0.01	0.02 0.02 - 0.02	0.03 0.02 - 0.04	0.07 0.05 - 0.09	0.10 0.07 - 0.12
Males										
Total, age 20–79	801	41.95	—	—	<LOD	<LOD	<LOD	0.02 0.02 - 0.02	0.04 0.03 - 0.06	0.06 0.04 - 0.08
20–39	240	84.17	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.03	0.04 <LOD - 0.08
40–59	281	33.81	0.02 0.01 - 0.02	0.01 0.01 - 0.02	<LOD	<LOD	0.01 0.01 - 0.02	0.02 0.02 - 0.03	0.04 0.03 - 0.05	0.06 0.04 - 0.07
60–79	280	13.93	0.05 0.03 - 0.06	0.02 0.02 - 0.03	<LOD	0.01 0.01 - 0.01	0.02 0.02 - 0.02	0.04 0.03 - 0.05	0.08 0.04 - 0.11	0.15 0.01 - 0.29
Females										
Total, age 20–79	867	52.36	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.03 0.03 - 0.04	0.05 0.04 - 0.06
20–39	286	88.46	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.02 <LOD - 0.04
40–59	315	43.49	—	—	<LOD	<LOD	0.01 0.01 - 0.01	0.02 0.02 - 0.03	0.03 0.03 - 0.04	0.04 0.04 - 0.05
60–79	266	24.06	0.03 0.02 - 0.03	0.02 0.01 - 0.02	<LOD	0.01 <LOD - 0.01	0.02 0.01 - 0.02	0.03 0.02 - 0.04	0.05 0.04 - 0.07	0.08 0.06 - 0.10

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.2.6b

Mirex (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	47.42	—	—	<LOD	<LOD	<LOD	3.03 2.47 - 3.59	6.13 4.82 - 7.44	9.08 6.54 - 11.62
20–39	525	86.67	—	—	<LOD	<LOD	<LOD	<LOD	1.93 <LOD - 3.09	3.27 <LOD - 7.31
40–59	596	38.93	3.04 2.38 - 3.70	2.03 1.72 - 2.39	<LOD	<LOD	2.05 1.67 - 2.44	3.42 2.56 - 4.28	6.25 4.78 - 7.72	8.52 6.24 - 10.80
60–79	545	18.90	5.34 3.82 - 6.87	2.98 2.53 - 3.50	<LOD	1.66 <LOD - 1.98	2.95 2.42 - 3.47	5.60 4.29 - 6.91	9.64 7.56 - 11.71	15.50 10.69 - 20.30
Males										
Total, age 20–79	801	41.95	—	—	<LOD	<LOD	<LOD	3.20 2.63 - 3.76	6.87 4.84 - 8.89	12.13 7.24 - 17.03
20–39	240	84.17	—	—	<LOD	<LOD	<LOD	<LOD	2.25 <LOD - 4.39	7.13 <LOD - 13.99
40–59	281	33.81	3.34 2.35 - 4.34	2.13 1.70 - 2.65	<LOD	<LOD	2.14 1.56 - 2.71	3.45 2.53 - 4.36	6.50 4.23 - 8.76	10.07 6.49 - 13.65
60–79	280	13.93	6.91 4.20 - 9.62	3.45 2.78 - 4.28	<LOD	1.98 1.60 - 2.37	3.23 2.67 - 3.80	5.84 4.49 - 7.20	12.68 6.05 - 19.31	23.68 <LOD - 47.52
Females										
Total, age 20–79	865	52.49	—	—	<LOD	<LOD	<LOD	2.87 2.26 - 3.48	5.80 4.47 - 7.12	7.61 6.17 - 9.05
20–39	285	88.77	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	3.04 <LOD - 5.29
40–59	315	43.49	—	—	<LOD	<LOD	1.95 1.50 - 2.41	3.20 2.08 - 4.33	5.82 4.25 - 7.39	7.54 6.26 - 8.82
60–79	265	24.15	3.89 3.17 - 4.61	2.60 2.15 - 3.13	<LOD	1.39 <LOD - 1.99	2.58 1.95 - 3.21	5.03 3.29 - 6.76	9.09 6.52 - 11.66	11.15 8.85 - 13.45

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

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8.2.7 Toxaphene (CASRN 8001-35-2)

Toxaphene is the common name for a complex mixture of polychlorinated camphenes, polychlorinated bornanes, and their derivatives. This synthetic chlorinated organic compound, or organochlorine, was once widely used as a broad-spectrum insecticide. Toxaphene is produced through the chlorination of camphene and the manufactured end product is a mixture of chemicals containing at least 180 to 190 different components (ATSDR, 1996; Fingerling et al., 1997).

Theoretically, there are 32 767 toxaphene congeners (De Geus et al., 2000). This summary addresses toxaphene in general and the two specific congeners measured in the CHMS, Parlar 26 and Parlar 50. These two congeners are among the most stable and persistent and, consequently, are the predominant congeners detected in human tissues (Ekici et al., 2008; Newsome & Ryan, 1999).

Toxaphene is a synthetic chemical and does not occur naturally in the environment. First developed in 1946, it became commercially available in

1949 (CCME, 1999; ATSDR, 1996). Toxaphene, which was widely used as a replacement for DDT due to its simple and cost-effective manufacturing process, became the most produced organochlorine insecticide worldwide (Korte et al., 1979). Because of its environmental persistence and toxicity, global toxaphene production and use declined throughout the late 1970s and early 1980s; a Canadian ban followed in 1982 (Chan & Yeboah, 2000; CCME, 1999). Toxaphene was never manufactured in Canada; however, global use of toxaphene from 1950 to 1992 has been estimated to exceed 1.3 million tonnes (Oehme, 2000; Voldner & Li, 1993; WHO, 1969).

As a contact insecticide, toxaphene was primarily utilized for application to agricultural crops, including cotton, cereal grains, fruits, nuts, oil seeds, soybeans, and vegetables. It also became widely used in livestock production for the control of ticks, mites, mange, lice, and other ectoparasites (IPCS, 1995; ATSDR, 1996). In the 1950s and 1960s, toxaphene was applied to lakes and streams in Canada to eliminate undesirable fish (Miskimmin & Schindler, 1994; Stern et al., 1996). Toxaphene was commonly mixed with other pesticides, including methyl or ethyl parathion, DDT, and lindane (IARC, 2001). The application of toxaphene likely persists in a number of developing countries due to allowable, yet restricted, usage (de Geus et al., 1999).

Toxaphene is persistent and volatile and, as a result, can migrate and concentrate in polar regions (ATSDR, 1996). Atmospheric deposition represents the main source of entry for this substance to the Canadian environment (CCME, 1999). Probable continued sources for the introduction of toxaphene to the Canadian environment include volatilization from contaminated soil and surface water present in historical high-use areas, erosion of toxaphene-contaminated soil contributing to toxaphene loading in surface waters, and ongoing use in other countries (CCME, 1999). Due to its slow degradation rate (an estimated soil half-life of up to 14 years), toxaphene applied in soils has been detectable decades later; toxaphene levels in most environmental media have not shown significant declines since the 1970s and 1980s (NTP, 2005; Van Oostdam et al., 2005).

The high diversity of toxaphene compounds and the concomitant presence of other organochlorine contaminants create intrinsic difficulties in the quantification of toxaphene in environmental media. Environmental concentrations vary widely based on the number of congeners used in the determination of total toxaphene concentrations and the analytical method used. Three congeners, Parlar numbers 26, 50 and 62, have become important in environmental monitoring due to their stability and because they represent the only isomers present in higher aquatic trophic levels (Frenzen et al., 1994).

The primary route of exposure to toxaphene for the public is through the ingestion of food containing trace levels of toxaphene, including breast milk; however, exposure can also occur from the inhalation of atmospheric contamination and direct dermal contact with a contaminated substance (ATSDR, 1996). As toxaphene accumulates in northern regions, northern Canadian populations, especially First Nations, Métis, and Inuit community members are more susceptible to potential exposure. Meat and organs from arctic mammals used as traditional food sources have been reported to have a mean toxaphene concentration ranging from <0.001 to 3.89 μg/g wet weight (IARC, 2001). People living near hazardous waste sites, or near land previously treated with toxaphene, also have increased potential for exposure.

Following exposure in humans, approximately 90% of the toxaphene that enters the body is excreted via urine and feces within 24 to 36 hours; however, a small percentage may remain in tissues with high lipid content (ATSDR, 1996). Toxaphene and its breakdown products can be detected in blood, urine, breast milk, and body tissues (ATSDR, 1996). Blood serum or plasma measurements of Parlar 26 and 50 are common biomarkers of exposure to toxaphene in humans (ATSDR, 1996; INAC, 2009).

Toxaphene has been classified as a possible human carcinogen (Group 2B) by the International Agency for Research on Cancer, based on insufficient human data and sufficient evidence of carcinogenicity in animals (IARC, 2001). It is listed as a probable carcinogen (2B) by the United States Environmental Protection Agency (US EPA, 1991). Neurotoxic effects, including effects on behaviour and learning, have been reported in animals, and *in vitro* studies have shown toxaphene and toxaphene congeners could be classified as weak mutagens and equivocal tumour promoters (de Geus et al., 1999; Van Oostdam et al., 2005). Animal studies have shown that long-term toxaphene exposure may cause liver, kidney, adrenal gland, and/or immune system damage and may cause minor fetal development changes (ATSDR, 1996). A provisional tolerable daily intake (pTDI) for toxaphene of 0.2 µg/kg body weight per day has been adopted by Health Canada (2007).

Toxaphene is considered to be of concern to the environment and to human health, and is managed under Track 1 of the Government of Canada's Toxic Substance Management Policy (Environment Canada, 2006). Although toxaphene use has decreased worldwide and has been banned in Canada since 1982, due to its persistence, it remains as an environmental contaminant today. Toxaphene is classified as a persistent organic pollutant (POP) by the Stockholm Convention, an international agreement to ban or severely restrict the production and use of POPs (UNEP, 2008).

The mean total toxaphene concentration measured in human breast milk of mothers living in northern Canada (Keewatin Region) was 67.7 ng/g, compared with the mean southern Canadian concentration of 6.03 ng/g. Mean concentrations of individual congeners Parlar 26 and Parlar 50 in the breast-milk samples from northern Canada were measured to be 24.9 ng/g and 33.1 ng/g, respectively. Mean concentrations of individual congeners Parlar 26 and Parlar 50 in the breast-milk samples from southern Canada were measured to be 1.32 ng/g and 2.35 ng/g, respectively (Newsome & Ryan, 1999). Toxaphene was measured in the plasma of mothers from the Inuvik region of the Canadian Arctic in 2005–2006. The geometric means of Parlar 50 in Dene, Métis, Inuvialuit, and non-aboriginal mothers was 0.46 (n = 17), 2.9 (n = 52), and 0.36 (n = 6) µg/kg plasma lipid, respectively (INAC, 2009). In a separate study in 2005–2007, levels of Parlar 50 in mothers from the Nunavut-Baffin Region had a geometric mean of 8.6 µg/kg plasma lipid (n = 99) (INAC, 2009).

Blood plasma levels of toxaphene Parlar 26 and toxaphene Parlar 50 were measured in a subset of the population aged 20–79 years participating in the Canadian Health Measures Survey and are presented as µg/L plasma and µg/kg lipid (Tables 8.2.7.1a – 8.2.7.2b). Participants were selected within the specified age range to be a representative sample of the Canadian population. Finding a measurable amount of toxaphene Parlar 26 or toxaphene Parlar 50 in blood plasma is an indicator of exposure to toxaphene and does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for blood plasma levels of toxaphene Parlar 26 and toxaphene Parlar 50 in the Canadian population.

8.2.7.1 Toxaphene Parlar 26

Table 8.2.7.1a

Toxaphene parlar 26– Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	73.71	—	—	<LOD	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.01 0.01 - 0.01
20–39	526	93.16	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01
40–59	596	79.19	—	—	<LOD	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.01 0.01 - 0.01
60–79	544	48.90	—	—	<LOD	<LOD	0.01 <LOD - 0.01	0.01 0.01 - 0.01	0.01 0.01 - 0.01	0.01 0.01 - 0.02
Males										
Total, age 20–79	801	70.79	—	—	<LOD	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.01 0.01 - 0.01
20–39	240	91.25	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	76.16	—	—	<LOD	<LOD	<LOD	<LOD <LOD - 0.01	0.01 <LOD - 0.01	0.01 0.01 - 0.01
60–79	280	47.86	—	—	<LOD	<LOD	0.01 <LOD - 0.01	0.01 0.01 - 0.01	0.01 0.01 - 0.02	0.02 0.01 - 0.02
Females										
Total, age 20–79	865	76.42	—	—	<LOD	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.01 0.01 - 0.01
20–39	286	94.76	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01
40–59	315	81.90	—	—	<LOD	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.01 0.01 - 0.01
60–79	264	50.00	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.01 0.01 - 0.01	0.01 0.01 - 0.02

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.2.7.1b

Toxaphene parlar 26 (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1664	73.80	—	—	<LOD	<LOD	<LOD	<LOD	1.14 0.91 - 1.37	1.57 1.18 - 1.96
20–39	525	93.33	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.74 <LOD - 1.13
40–59	596	79.19	—	—	<LOD	<LOD	<LOD	<LOD	1.06 0.68 - 1.45	1.54 0.89 - 2.18
60–79	543	48.99	—	—	<LOD	<LOD	0.68 <LOD - 0.93	1.19 1.01 - 1.37	1.85 1.51 - 2.19	2.17 1.43 - 2.91
Males										
Total, age 20–79	801	70.79	—	—	<LOD	<LOD	<LOD	<LOD	1.17 0.86 - 1.48	1.88 1.40 - 2.37
20–39	240	91.25	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	76.16	—	—	<LOD	<LOD	<LOD	<LOD <LOD - 1.11	1.07 <LOD - 1.67	1.86 1.06 - 2.67
60–79	280	47.86	—	—	<LOD	<LOD	0.87 <LOD - 1.22	1.36 1.10 - 1.62	2.02 1.32 - 2.72	2.75 1.21 - 4.30
Females										
Total, age 20–79	863	76.59	—	—	<LOD	<LOD	<LOD	<LOD	1.10 0.86 - 1.35	1.39 1.05 - 1.74
20–39	285	95.09	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	1.07 <LOD - 1.69
40–59	315	81.90	—	—	<LOD	<LOD	<LOD	<LOD	1.06 0.76 - 1.35	1.32 0.71 - 1.93
60–79	263	50.19	—	—	<LOD	<LOD	<LOD	1.13 0.89 - 1.38	1.57 1.22 - 1.93	1.88 1.61 - 2.16

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.2.7.2 Toxaphene Parlar 50

Table 8.2.7.2a

Toxaphene parlar 50 – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1667	52.31	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.01 0.01 - 0.01	0.01 0.01 - 0.02
20–39	526	83.08	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.01 0.01 - 0.01
40–59	596	52.68	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.01 0.01 - 0.01	0.01 0.01 - 0.02
60–79	545	22.20	0.01 0.01 - 0.01	0.01 0.01 - 0.01	<LOD	<LOD <LOD - 0.01	0.01 0.01 - 0.01	0.01 0.01 - 0.01	0.02 0.01 - 0.02	0.02 0.02 - 0.03
Males										
Total, age 20–79	801	47.94	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.01 0.01 - 0.01	0.02 0.01 - 0.02
20–39	240	78.75	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.01 0.01 - 0.01
40–59	281	47.33	—	—	<LOD	<LOD	<LOD <LOD - 0.01	0.01 0.01 - 0.01	0.01 0.01 - 0.02	0.02 0.01 - 0.03
60–79	280	22.14	0.01 0.01 - 0.01	0.01 0.01 - 0.01	<LOD	<LOD <LOD - 0.01	0.01 0.01 - 0.01	0.01 0.01 - 0.02	0.02 0.01 - 0.03	0.03 0.02 - 0.03
Females										
Total, age 20–79	866	56.35	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.01 0.01 - 0.01	0.01 0.01 - 0.02
20–39	286	86.71	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.01 <LOD - 0.01
40–59	315	57.46	—	—	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.01 0.01 - 0.01	0.01 0.01 - 0.01
60–79	265	22.26	0.01 0.01 - 0.01	0.01 0.01 - 0.01	<LOD	<LOD <LOD - 0.01	0.01 0.01 - 0.01	0.01 0.01 - 0.01	0.02 0.01 - 0.02	0.02 0.01 - 0.02

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.2.7.2b

Toxaphene parlar 50 (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1665	52.37	—	—	<LOD	<LOD	<LOD	1.15 0.96 - 1.34	1.73 1.42 - 2.05	2.40 1.80 - 3.00
20–39	525	83.24	—	—	<LOD	<LOD	<LOD	<LOD	1.01 <LOD - 1.27	1.26 0.87 - 1.64
40–59	596	52.68	—	—	<LOD	<LOD	<LOD	1.20 0.97 - 1.43	1.70 1.25 - 2.15	2.39 1.25 - 3.53
60–79	544	22.24	1.44 1.15 - 1.72	1.11 0.93 - 1.31	<LOD	<LOD <LOD - 0.89	1.20 1.04 - 1.36	1.73 1.43 - 2.03	2.59 2.01 - 3.16	3.35 2.27 - 4.42
Males										
Total, age 20–79	801	47.94	—	—	<LOD	<LOD	<LOD	1.19 1.04 - 1.34	1.82 1.16 - 2.48	2.68 1.53 - 3.83
20–39	240	78.75	—	—	<LOD	<LOD	<LOD	<LOD	0.99 <LOD - 1.27	1.18 0.97 - 1.39
40–59	281	47.33	—	—	<LOD	<LOD	<LOD <LOD - 1.05	1.21 1.00 - 1.42	1.82 0.58 - 3.06	3.26 1.74 - 4.79
60–79	280	22.14	1.63 1.21 - 2.05	1.22 0.99 - 1.50	<LOD	<LOD <LOD - 1.03	1.32 1.11 - 1.54	1.97 1.47 - 2.46	3.04 1.96 - 4.13	4.19 2.06 - 6.32
Females										
Total, age 20–79	864	56.48	—	—	<LOD	<LOD	<LOD	1.08 0.85 - 1.31	1.71 1.37 - 2.04	2.01 1.65 - 2.37
20–39	285	87.02	—	—	<LOD	<LOD	<LOD	<LOD	1.01 <LOD - 1.46	1.63 <LOD - 2.52
40–59	315	57.46	—	—	<LOD	<LOD	<LOD	1.16 <LOD - 1.49	1.44 1.00 - 1.88	1.81 1.40 - 2.22
60–79	264	22.35	1.26 1.05 - 1.46	1.01 0.86 - 1.18	<LOD	<LOD <LOD - 0.82	1.04 0.87 - 1.22	1.63 1.37 - 1.89	2.25 1.81 - 2.70	2.95 2.23 - 3.68

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

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8.3 POLYCHLORINATED BIPHENYLS (CAS 1336-36-3)

Polychlorinated biphenyls (PCBs) are a group of synthetic chlorinated organic compounds that do not occur naturally in the environment. They were produced synthetically as mixtures for various applications up until the late 1970s mainly in the United States, but also in other countries such as Germany, Italy, France, and Japan (ATSDR, 2000). Products containing PCBs include electrical capacitors and transformers, heat transfer and hydraulic fluids, flame retardants, inks, adhesives, lubricants, surface coatings, anti-fouling agents, and plasticizers (ATSDR, 2000). PCBs have never been manufactured in Canada, and have not been produced in the United States since 1979 (ATSDR, 2000; CCME, 2001). Use of PCBs has been restricted in Canada since 1977 (Environment Canada, 1997) and is currently limited to products in use prior to 1977.

There are 209 possible chemicals (called congeners) within the PCB group. The basic chemical structure consists of a biphenyl molecule with up to ten chlorine atoms substituted for hydrogen atoms at different positions around the biphenyl molecule. The PCB congeners are named based on their structure (e.g., 2,4,4'-trichlorobiphenyl), but are more commonly referred to by their IUPAC (International Union of Pure and Applied Chemistry) number. This approach systematically assigns numbers to the different congeners, with higher numbers assigned to congeners with a larger number of chlorine atoms. Commercial mixtures of PCBs are also known under several trade names, including Aroclor, Chloretol, Dyknol, Inerteem, Kanechlor, Noflamol, Phenoclor, and Pyranol (ATSDR, 2000).

Blood samples from participants in the CHMS were assessed not only for individual PCB congeners, but also for the level of Aroclor 1260 (CASRN 11096-82-5), a technical mixture of PCBs containing approximately 60% chlorine. In this survey, the concentration of Aroclor 1260 was calculated according to a specific formula that has been widely adopted in other studies (Kearney et al., 1999; Butler Walker et al., 2003; Van Oostdam et al., 2005). For each participant, the concentrations of PCBs 138 and 153 were added and this sum was then multiplied by a factor of 5.2, which corresponds to the correlation between the concentration of Aroclor 1260 and the concentrations of PCBs 138 and 153 (Patterson et al., 1991; NIOSH, 1997). In the current survey, Aroclor 1260 was calculated in this manner in order to allow comparisons to older studies, where PCB data was commonly expressed as commercial mixtures, since the analytical methods used did not have sufficient resolution to identify individual PCB congeners.

This summary addresses PCBs in general and specifically the following congeners measured in the Canadian Health Measures Survey:

IUPAC No.	Congener Name	CASRN
PCB 28	2,4,4'-Trichlorobiphenyl	7012-37-5
PCB 52	2,2',5,5'-Tetrachlorobiphenyl	35693-99-3
PCB 66	2,3',4,4'-Tetrachlorobiphenyl	32598-10-0
PCB 74	2,4,4',5-Tetrachlorobiphenyl	32690-93-0
PCB 99	2,2',4,4',5-Pentachlorobiphenyl	38380-01-7
PCB 101	2,2',4,5,5'-Pentachlorobiphenyl	37680-73-2
PCB 105	2,3,3',4,4'-Pentachlorobiphenyl	32598-14-4
PCB 118	2,3',4,4',5-Pentachlorobiphenyl	31508-00-6
PCB 128	2,2',3,3',4,4'-Hexachlorobiphenyl	38380-07-3
PCB 138	2,2',3,4,4',5'-Hexachlorobiphenyl	35065-28-2

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IUPAC No.	Congener Name	CASRN
PCB 146	2,2',3,4',5,5'-Hexachlorobiphenyl	51908-16-8
PCB 153	2,2',4,4',5,5'-Hexachlorobiphenyl	35065-27-1
PCB 156	2,3,3',4,4',5-Hexachlorobiphenyl	38380-08-4
PCB 163	2,3,3',4',5,6-Hexachlorobiphenyl	74472-44-9
PCB 167	2,3',4,4',5,5'-Hexachlorobiphenyl	52663-72-6
PCB 170	2,2',3,3',4,4',5-Heptachlorobiphenyl	35065-30-6
PCB 178	2,2',3,3',5,5',6-Heptachlorobiphenyl	52663-67-9
PCB 180	2,2',3,4,4',5,5'-Heptachlorobiphenyl	35065-29-3
PCB 183	2,2',3,4,4',5',6-Heptachlorobiphenyl	52663-69-1
PCB 187	2,2',3,4',5,5',6-Heptachlorobiphenyl	52663-68-0
PCB 194	2,2',3,3',4,4',5,5'-Octachlorobiphenyl	35694-08-7
PCB 201	2,2',3,3',4,5',6,6'-Octachlorobiphenyl	40186-71-8
PCB 203	2,2',3,4,4',5,5',6-Octachlorobiphenyl	52663-76-0
PCB 206	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	40186-72-9

Through use or improper disposal practices, PCBs can enter the environment through emissions to air, water, soil, or dust. PCBs are persistent and the congeners with higher numbers of chlorine atoms tend to have longer half-lives. As a result of this persistence, PCBs in the environment are available for uptake by plants and animals, and can be magnified manyfold in the food chain. Thus, while exposure to PCBs in other media may contribute to an individual's total body burden, the predominant source of exposure is the diet, including breast milk (IPCS, 2003; INSPQ, 2006).

Exposure to PCBs usually involves mixtures of individual PCB congeners. The PCBs accumulate in human adipose tissue (IPCS, 2003), and measured concentrations in fatty tissues are often used as indicators of exposure (ATSDR, 2000). PCBs 138, 153, and 180 are the most commonly found PCBs in human tissues (ATSDR, 2000).

Estimated dietary intake of PCBs in the United States and Canada has been decreasing since 1978 (ATSDR, 2000; INSPQ, 2006), and PCB concentrations decreased markedly in Canadian mothers' breast milk between 1982 and 1992 (Craan & Haines, 1998). Current dietary intake in Canada, based on the most recent Total Diet Study, varies from 4.97–9.65 ng/kg body weight/day for infants, 7.22 ng/kg body weight/day for children 1–4 years, and 1.16–2.67 ng/kg body weight/day for adults 20+ years (Health Canada, 2009).

PCBs are metabolized by various cytochrome P-450 enzymes to polar metabolites that can undergo conjugation with glutathione and glucuronic acid. The major routes of excretion of PCBs are fecal and, especially for its metabolites, urinary (ATSDR, 2000). PCB profiles in human serum immediately following exposures reflect the profiles in the exposure sources; however, selective metabolism, excretion, and deposition begin to alter the congener profile within four to 24 hours. Thus, in most cases, the PCB profile in adults represents a steady state body burden that does not match the profile of environmental mixtures of commercial PCB formulations (Aroclors, etc.) (ATSDR, 2000).

Animal studies have shown that exposures to high levels of PCBs can have detrimental effects on the liver, endocrine system, skin, immune system, nervous system, reproductive system, and fetal and infant development (ATSDR, 2000; WHO, 2000; CCME, 2001). Human studies of PCB toxicity have generally been limited by the inability to distinguish effects from other contaminants that were present during PCB exposure and by varying methodologies for assessing exposure (WHO, 2000; INSPQ, 2006). Several birth cohort studies have shown that developmental neurotoxicity may be associated with prenatal, perinatal, and/or postnatal exposure to PCBs even at background environmental levels, although the results are inconsistent (Hertz-Picciotto et al., 2005; Koopman-Esseboom et al., 1994; Walkowiak et al., 2001 Wilhelm et al., 2008). Such inconsistencies may be associated with the differences in exposure assessment methods and study design, as well as the general decrease in PCB exposure resulting in more subtle and less easily detectable effects.

PCBs are considered to be of concern to the environment and to human health and are managed under Track 1 of the Government of Canada's Toxic Substances Management Policy (Environment Canada, 1997). PCBs are of concern due to potential higher body loads in humans resulting from accumulation in fat tissue that could eventually become detrimental to health (Health Canada, 1994). They are on the Export Control List in Part 2, Schedule 3 of the *Canadian Environmental Protection Act, 1999* as "substances subject to notification and consent", and Environment Canada maintains an inventory of PCB use and stored PCB waste within Canada (Environment Canada, 2006). The International Agency for Research on Cancer classified PCBs as Group 2A (a probable human carcinogen) (IARC, 1987). PCBs are classified as persistent organic pollutants (POP) by the Stockholm Convention, an international agreement to ban or severely restrict the production and use of POPs (UNEP, 2008).

In an exposure assessment study carried out in 1992 in two separate regions in the Great Lakes area of Ontario, 232 participants were assessed for the levels of environmental contaminants in blood plasma samples. The measured respective geometric mean and maximum concentrations were 43.4 and 242.9 µg/kg plasma lipid for PCB 138; 57.2 and 259.0 µg/kg plasma lipid for PCB 153; and 41.5 and 235.0 µg/kg plasma lipid for PCB 180 (Kearney et al., 1999).

Blood plasma levels of PCBs were measured in a subset of the CHMS population aged 20–79, and are presented as µg/L plasma and µg/kg lipid (Tables 8.3.1a – 8.3.25b). Participants were selected within the specified age range to be a representative sample of the Canadian population. Finding a measurable amount of PCBs in plasma is an indicator of exposure to PCBs and does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for blood plasma levels of PCBs in the Canadian population.

8.3.1 2,4,4'-Trichlorobiphenyl (PCB 28)

Table 8.3.1a

2,4,4'-Trichlorobiphenyl (PCB 28)– Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1661	98.62	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	523	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	595	99.33	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	543	96.50	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	800	98.88	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	239	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	99.64	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	97.14	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	861	98.37	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	284	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	314	99.04	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	263	95.82	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.1b

2,4,4'-Trichlorobiphenyl (PCB 28) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1659	98.73	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	522	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	595	99.33	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	542	96.68	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	800	98.88	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	239	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	99.64	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	97.14	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	859	98.60	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	283	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	314	99.04	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	262	96.18	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.2 2,2',5,5'-Tetrachlorobiphenyl (PCB 52)

Table 8.3.2a

2,2',5,5'-Tetrachlorobiphenyl (PCB 52)– Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1661	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	523	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	595	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	543	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	800	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	239	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	861	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	284	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	314	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	263	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.2b

2,2',5,5'-Tetrachlorobiphenyl (PCB 52) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1659	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	522	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	595	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	542	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	800	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	239	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	859	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	283	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	314	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	262	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.3 2,3',4,4'-Tetrachlorobiphenyl (PCB 66)

Table 8.3.3a

2,3',4,4'-Tetrachlorobiphenyl (PCB 66)– Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	98.20	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	526	99.43	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	596	98.66	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	544	96.51	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	801	98.25	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	99.58	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	98.58	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	96.79	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	865	98.15	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	286	99.30	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	315	98.73	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	264	96.21	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.3b

2,3',4,4'-Tetrachlorobiphenyl (PCB 66) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (μg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95% CI	G.M. 95% CI	10th 95% CI	25th 95% CI	50th 95% CI	75th 95% CI	90th 95% CI	95th 95% CI
Total, age 20–79	1664	98.32	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	525	99.62	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	596	98.66	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	543	96.69	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	801	98.25	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	99.58	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	98.58	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	96.79	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	863	98.38	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	285	99.65	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	315	98.73	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	263	96.58	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.4 2,4,4',5-Tetrachlorobiphenyl (PCB 74)

Table 8.3.4a

2,4,4',5-Tetrachlorobiphenyl (PCB 74)– Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	53.06	—	—	<LOD	<LOD	<LOD	0.04 0.04 - 0.05	0.08 0.07 - 0.09	0.10 0.09 - 0.12
20–39	526	90.49	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.04 <LOD - 0.06
40–59	596	54.53	—	—	<LOD	<LOD	<LOD	0.04 0.04 - 0.05	0.07 0.06 - 0.07	0.08 0.07 - 0.10
60–79	546	15.38	0.07 0.06 - 0.08	0.06 0.05 - 0.06	<LOD	0.04 0.03 - 0.04	0.06 0.05 - 0.07	0.09 0.08 - 0.10	0.14 0.11 - 0.16	0.16 0.13 - 0.20
Males										
Total, age 20–79	801	59.55	—	—	<LOD	<LOD	<LOD	0.03 0.03 - 0.04	0.06 0.05 - 0.07	0.08 0.06 - 0.10
20–39	240	93.33	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.03 <LOD - 0.09
40–59	281	67.26	—	—	<LOD	<LOD	<LOD	0.03 <LOD - 0.04	0.04 0.03 - 0.05	0.06 0.05 - 0.07
60–79	280	22.86	0.06 0.05 - 0.08	0.05 0.04 - 0.05	<LOD	0.03 <LOD - 0.04	0.05 0.04 - 0.05	0.07 0.05 - 0.09	0.11 0.07 - 0.15	0.16 0.11 - 0.21
Females										
Total, age 20–79	867	47.06	—	—	<LOD	<LOD	<LOD	0.06 0.05 - 0.06	0.09 0.08 - 0.10	0.11 0.09 - 0.13
20–39	286	88.11	—	—	<LOD	<LOD	<LOD	<LOD	<LOD <LOD - 0.05	0.04 <LOD - 0.05
40–59	315	43.17	—	—	<LOD	<LOD	0.03 <LOD - 0.04	0.06 0.05 - 0.06	0.08 0.06 - 0.09	0.09 0.07 - 0.12
60–79	266	7.52	0.08 0.07 - 0.10	0.07 0.05 - 0.08	<LOD	0.04 0.03 - 0.05	0.07 0.06 - 0.08	0.10 0.09 - 0.11	0.14 0.12 - 0.17	0.17 0.12 - 0.22

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.4b

2,4,4',5-Tetrachlorobiphenyl (PCB 74) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	53.12	—	—	<LOD	<LOD	<LOD	6.92 5.94 - 7.89	11.89 10.77 - 13.00	15.98 12.87 - 19.09
20–39	525	90.67	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	6.65 <LOD - 9.56
40–59	596	54.53	—	—	<LOD	<LOD	<LOD	6.64 5.73 - 7.55	10.61 8.88 - 12.34	12.97 10.20 - 15.74
60–79	545	15.41	11.25 9.64 - 12.86	8.55 7.40 - 9.88	<LOD	5.89 4.74 - 7.04	9.06 7.56 - 10.57	13.53 11.69 - 15.37	20.85 16.93 - 24.77	25.24 21.64 - 28.84
Males										
Total, age 20–79	801	59.55	—	—	<LOD	<LOD	<LOD	5.20 4.15 - 6.25	9.86 8.03 - 11.70	12.30 10.30 - 14.30
20–39	240	93.33	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	6.21 <LOD - 11.78
40–59	281	67.26	—	—	<LOD	<LOD	<LOD	4.71 <LOD - 5.66	6.55 5.46 - 7.64	9.02 5.97 - 12.07
60–79	280	22.86	10.09 8.13 - 12.06	7.19 6.13 - 8.44	<LOD	4.01 <LOD - 5.46	7.09 5.65 - 8.52	11.41 9.99 - 12.83	19.75 13.42 - 26.07	24.63 19.72 - 29.54
Females										
Total, age 20–79	865	47.17	—	—	<LOD	<LOD	<LOD	8.56 7.57 - 9.56	13.90 12.07 - 15.74	17.69 13.10 - 22.29
20–39	285	88.42	—	—	<LOD	<LOD	<LOD	<LOD	<LOD <LOD - 6.83	6.65 <LOD - 8.17
40–59	315	43.17	—	—	<LOD	<LOD	5.06 <LOD - 6.39	8.63 7.44 - 9.81	12.56 10.19 - 14.92	15.28 9.93 - 20.64
60–79	265	7.55	12.32 10.30 - 14.35	10.04 8.42 - 11.98	<LOD	7.17 5.85 - 8.50	10.85 9.57 - 12.13	14.92 12.55 - 17.28	21.69 18.01 - 25.37	25.51 21.07 - 29.96

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.5 2,2',4,4',5-Pentachlorobiphenyl (PCB 99)

Table 8.3.5a

2,2',4,4',5-Pentachlorobiphenyl (PCB 99)– Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	70.56	—	—	<LOD	<LOD	<LOD	<LOD <LOD - 0.04	0.05 0.04 - 0.06	0.07 0.06 - 0.09
20–39	526	95.44	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD <LOD - 0.04
40–59	596	73.32	—	—	<LOD	<LOD	<LOD	0.03 <LOD - 0.04	0.05 0.04 - 0.06	0.06 0.04 - 0.09
60–79	546	43.59	—	—	<LOD	<LOD	0.03 <LOD - 0.04	0.05 0.04 - 0.06	0.08 0.06 - 0.10	0.12 0.09 - 0.14
Males										
Total, age 20–79	801	73.03	—	—	<LOD	<LOD	<LOD	<LOD	0.05 0.03 - 0.06	0.07 0.05 - 0.09
20–39	240	95.83	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.04 <LOD - 0.10
40–59	281	79.36	—	—	<LOD	<LOD	<LOD	<LOD	0.04 0.04 - 0.05	0.06 0.04 - 0.08
60–79	280	47.14	—	—	<LOD	<LOD	0.03 <LOD - 0.04	0.05 0.04 - 0.06	0.08 0.04 - 0.12	0.12 0.08 - 0.16
Females										
Total, age 20–79	867	68.28	—	—	<LOD	<LOD	<LOD	0.03 <LOD - 0.04	0.05 0.04 - 0.06	0.07 0.05 - 0.09
20–39	286	95.10	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	315	67.94	—	—	<LOD	<LOD	<LOD	0.04 <LOD - 0.04	0.06 0.04 - 0.08	0.07 0.04 - 0.10
60–79	266	39.85	0.04 0.03 - 0.05	0.03 <LOD - 0.04	<LOD	<LOD	0.03 <LOD - 0.04	0.05 0.04 - 0.06	0.08 0.06 - 0.10	0.10 0.07 - 0.13

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.5b

2,2',4,4',5-Pentachlorobiphenyl (PCB 99) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95% CI	G.M. 95% CI	10th 95% CI	25th 95% CI	50th 95% CI	75th 95% CI	90th 95% CI	95th 95% CI
Total, age 20–79	1666	70.65	—	—	<LOD	<LOD	<LOD	<LOD <LOD - 4.93	7.81 6.71 - 8.91	11.32 9.13 - 13.52
20–39	525	95.62	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD <LOD - 8.37
40–59	596	73.32	—	—	<LOD	<LOD	<LOD	4.63 <LOD - 5.72	7.51 6.04 - 8.99	11.27 8.14 - 14.39
60–79	545	43.67	—	—	<LOD	<LOD	5.08 <LOD - 5.93	7.70 6.76 - 8.65	12.72 10.23 - 15.20	16.09 12.91 - 19.27
Males										
Total, age 20–79	801	73.03	—	—	<LOD	<LOD	<LOD	<LOD	7.84 6.01 - 9.67	11.06 7.92 - 14.21
20–39	240	95.83	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	7.39 <LOD - 13.76
40–59	281	79.36	—	—	<LOD	<LOD	<LOD	<LOD	6.43 5.25 - 7.62	9.03 6.41 - 11.64
60–79	280	47.14	—	—	<LOD	<LOD	4.75 <LOD - 6.25	7.80 6.17 - 9.44	13.31 10.22 - 16.41	16.56 10.00 - 23.13
Females										
Total, age 20–79	865	68.44	—	—	<LOD	<LOD	<LOD	4.81 <LOD - 5.61	7.79 5.99 - 9.59	11.91 9.20 - 14.62
20–39	285	95.44	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	315	67.94	—	—	<LOD	<LOD	<LOD	5.49 <LOD - 7.20	9.75 5.62 - 13.89	12.75 9.31 - 16.19
60–79	265	40.00	6.20 5.16 - 7.25	4.81 <LOD - 5.48	<LOD	<LOD	5.10 <LOD - 6.01	7.63 6.56 - 8.71	12.01 8.68 - 15.34	15.93 11.97 - 19.90

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.6 2,2',4,5,5'-Pentachlorobiphenyl (PCB 101)

Table 8.3.6a

2,2',4,5,5'-Pentachlorobiphenyl (PCB 101)– Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95% CI	G.M. 95% CI	10th 95% CI	25th 95% CI	50th 95% CI	75th 95% CI	90th 95% CI	95th 95% CI
Total, age 20–79	1666	99.40	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	526	99.81	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	596	99.50	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	544	98.90	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	801	99.38	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	99.29	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	98.93	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	865	99.42	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	286	99.65	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	315	99.68	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	264	98.86	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.6b

2,2',4,5,5'-Pentachlorobiphenyl (PCB 101) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (μg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95% CI	G.M. 95% CI	10th 95% CI	25th 95% CI	50th 95% CI	75th 95% CI	90th 95% CI	95th 95% CI
Total, age 20–79	1664	99.52	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	525	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	596	99.50	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	543	99.08	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	801	99.38	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	99.29	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	98.93	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	863	99.65	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	285	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	315	99.68	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	263	99.24	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.7 2,3,3',4,4'-Pentachlorobiphenyl (PCB 105)

Table 8.3.7a

2,3,3',4,4'-Pentachlorobiphenyl (PCB 105) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	71.10	—	—	<LOD	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.02 0.02 - 0.03
20–39	526	94.11	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD <LOD - 0.02
40–59	596	75.34	—	—	<LOD	<LOD	<LOD	<LOD <LOD - 0.01	0.01 0.01 - 0.02	0.02 <LOD - 0.03
60–79	546	44.32	—	—	<LOD	<LOD	0.01 <LOD - 0.02	0.02 0.01 - 0.02	0.03 0.02 - 0.04	0.04 0.02 - 0.07
Males										
Total, age 20–79	801	74.91	—	—	<LOD	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.02 0.01 - 0.03
20–39	240	95.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD <LOD - 0.02
40–59	281	80.78	—	—	<LOD	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.02 0.01 - 0.02
60–79	280	51.79	—	—	<LOD	<LOD	<LOD	0.01 <LOD - 0.02	0.02 0.01 - 0.04	0.05 <LOD - 0.09
Females										
Total, age 20–79	867	67.59	—	—	<LOD	<LOD	<LOD	0.01 <LOD - 0.02	0.02 0.01 - 0.02	0.02 0.02 - 0.03
20–39	286	93.36	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD <LOD - 0.01
40–59	315	70.48	—	—	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.02 <LOD - 0.02	0.02 0.01 - 0.04
60–79	266	36.47	0.02 0.01 - 0.02	0.01 <LOD - 0.01	<LOD	<LOD	0.01 <LOD - 0.02	0.02 0.01 - 0.02	0.03 0.02 - 0.04	0.04 0.03 - 0.06

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.7b

2,3,3',4,4'-Pentachlorobiphenyl (PCB 105) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (μg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	71.19	—	—	<LOD	<LOD	<LOD	<LOD	2.43 2.02 - 2.84	3.58 2.63 - 4.53
20–39	525	94.29	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD <LOD - 2.07
40–59	596	75.34	—	—	<LOD	<LOD	<LOD	<LOD <LOD - 1.79	2.39 1.95 - 2.82	3.43 <LOD - 4.59
60–79	545	44.40	—	—	<LOD	<LOD	1.43 <LOD - 2.00	2.47 1.82 - 3.11	4.43 2.79 - 6.07	6.94 4.76 - 9.11
Males										
Total, age 20–79	801	74.91	—	—	<LOD	<LOD	<LOD	<LOD	1.99 1.72 - 2.25	3.13 1.90 - 4.36
20–39	240	95.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD <LOD - 1.99
40–59	281	80.78	—	—	<LOD	<LOD	<LOD	<LOD	1.82 1.58 - 2.05	2.09 1.29 - 2.90
60–79	280	51.79	—	—	<LOD	<LOD	<LOD	2.27 <LOD - 3.10	4.18 1.63 - 6.74	6.73 <LOD - 10.30
Females										
Total, age 20–79	865	67.75	—	—	<LOD	<LOD	<LOD	1.60 <LOD - 1.96	2.72 2.21 - 3.23	3.93 3.00 - 4.86
20–39	285	93.68	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD <LOD - 2.89
40–59	315	70.48	—	—	<LOD	<LOD	<LOD	1.76 <LOD - 2.20	2.70 <LOD - 3.48	3.71 2.41 - 5.01
60–79	265	36.60	2.33 1.78 - 2.87	1.71 <LOD - 2.07	<LOD	<LOD	1.69 <LOD - 2.21	2.68 1.95 - 3.42	4.61 2.58 - 6.63	6.97 4.67 - 9.28

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.8 2,3',4,4',5-Pentachlorobiphenyl (PCB 118)

Table 8.3.8a

2,3',4,4',5-Pentachlorobiphenyl (PCB 118) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	9.65	0.04 0.04 - 0.05	0.03 0.02 - 0.03	<LOD	0.01 0.01 - 0.02	0.03 0.02 - 0.03	0.05 0.04 - 0.06	0.09 0.07 - 0.10	0.12 0.10 - 0.14
20–39	526	23.00	0.02 0.02 - 0.02	0.01 0.01 - 0.02	<LOD	0.01 <LOD - 0.01	0.02 0.01 - 0.02	0.02 0.02 - 0.03	0.04 0.03 - 0.05	0.05 0.03 - 0.06
40–59	596	6.38	0.04 0.03 - 0.05	0.03 0.03 - 0.03	0.01 <LOD - 0.02	0.02 0.01 - 0.02	0.03 0.02 - 0.03	0.05 0.04 - 0.06	0.08 0.07 - 0.08	0.10 0.08 - 0.13
60–79	546	0.37	0.09 0.06 - 0.11	0.06 0.05 - 0.08	0.02 0.02 - 0.03	0.03 0.03 - 0.04	0.06 0.05 - 0.07	0.10 0.09 - 0.12	0.15 0.11 - 0.20	0.25 0.18 - 0.31
Males										
Total, age 20–79	801	11.61	0.04 0.03 - 0.05	0.02 0.02 - 0.03	<LOD	0.01 0.01 - 0.02	0.02 0.02 - 0.03	0.04 0.03 - 0.05	0.07 0.06 - 0.08	0.11 0.08 - 0.14
20–39	240	30.42	0.02 0.01 - 0.02	0.01 0.01 - 0.02	<LOD	<LOD	0.01 0.01 - 0.02	0.02 0.02 - 0.03	0.03 0.02 - 0.04	0.04 0.02 - 0.06
40–59	281	6.41	0.03 0.03 - 0.04	0.03 0.02 - 0.03	0.01 <LOD - 0.01	0.02 0.01 - 0.02	0.02 0.02 - 0.03	0.04 0.03 - 0.05	0.06 0.05 - 0.07	0.07 0.06 - 0.09
60–79	280	0.71	0.09 0.04 - 0.13	0.06 0.04 - 0.07	0.02 0.02 - 0.03	0.03 0.02 - 0.04	0.05 0.04 - 0.07	0.09 0.06 - 0.12	0.14 0.07 - 0.21	0.23 0.13 - 0.33
Females										
Total, age 20–79	867	7.84	0.05 0.04 - 0.05	0.03 0.03 - 0.04	<LOD <LOD - 0.02	0.02 0.01 - 0.02	0.03 0.03 - 0.04	0.06 0.05 - 0.07	0.10 0.08 - 0.12	0.13 0.11 - 0.15
20–39	286	16.78	0.02 0.02 - 0.03	0.02 0.01 - 0.02	<LOD	0.01 <LOD - 0.02	0.02 0.01 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.05	0.05 0.03 - 0.06
40–59	315	6.35	0.05 0.04 - 0.06	0.03 0.03 - 0.04	0.01 <LOD - 0.02	0.02 0.01 - 0.03	0.04 0.03 - 0.04	0.07 0.06 - 0.08	0.09 0.07 - 0.11	0.12 0.09 - 0.15
60–79	266	0.00	0.09 0.07 - 0.11	0.07 0.06 - 0.08	0.03 0.02 - 0.03	0.04 0.03 - 0.05	0.07 0.06 - 0.09	0.11 0.09 - 0.13	0.16 0.09 - 0.22	0.25 0.16 - 0.33

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.8b

2,3',4,4',5-Pentachlorobiphenyl (PCB 118) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	9.66	6.93 5.66 - 8.20	4.43 3.78 - 5.20	<LOD	2.49 2.00 - 2.99	4.23 3.60 - 4.87	8.07 6.58 - 9.57	13.64 12.20 - 15.08	20.29 15.33 - 25.26
20–39	525	23.05	3.40 2.75 - 4.04	2.63 2.18 - 3.17	<LOD	1.62 <LOD - 2.37	2.76 2.24 - 3.29	4.18 3.18 - 5.17	6.78 5.08 - 8.47	8.70 6.42 - 10.98
40–59	596	6.38	6.65 5.61 - 7.69	4.80 4.08 - 5.65	1.92 <LOD - 2.58	3.11 2.50 - 3.71	4.52 3.83 - 5.20	8.07 6.52 - 9.62	12.97 10.99 - 14.95	16.79 11.65 - 21.94
60–79	545	0.37	13.81 9.90 - 17.72	9.67 8.01 - 11.68	3.74 3.08 - 4.40	5.55 4.37 - 6.73	9.62 7.36 - 11.88	14.83 12.06 - 17.60	25.36 18.78 - 31.95	35.67 26.15 - 45.19
Males										
Total, age 20–79	801	11.61	6.20 4.35 - 8.05	3.83 3.19 - 4.60	<LOD	2.22 1.81 - 2.63	3.69 3.15 - 4.23	6.49 5.42 - 7.57	11.58 9.74 - 13.41	15.08 8.34 - 21.82
20–39	240	30.42	2.90 2.13 - 3.68	2.25 1.76 - 2.89	<LOD	<LOD	2.30 1.69 - 2.91	3.44 2.57 - 4.32	6.03 4.19 - 7.88	7.19 4.81 - 9.57
40–59	281	6.41	5.62 4.51 - 6.72	4.18 3.53 - 4.96	2.03 <LOD - 2.54	2.77 2.19 - 3.35	4.07 3.45 - 4.69	5.93 4.76 - 7.11	8.89 6.11 - 11.67	11.61 8.51 - 14.71
60–79	280	0.71	13.70 6.95 - 20.44	8.80 6.90 - 11.23	3.42 2.78 - 4.06	4.96 3.65 - 6.27	8.20 5.29 - 11.12	13.09 10.21 - 15.96	22.62 11.17 - 34.07	32.97 20.77 - 45.17
Females										
Total, age 20–79	865	7.86	7.66 6.44 - 8.89	5.13 4.37 - 6.04	<LOD <LOD - 2.37	3.05 2.44 - 3.65	4.96 3.98 - 5.95	9.73 7.99 - 11.48	15.62 13.16 - 18.08	22.13 17.25 - 27.02
20–39	285	16.84	3.92 3.08 - 4.76	3.09 2.44 - 3.90	<LOD	2.04 <LOD - 2.93	3.29 2.73 - 3.84	5.02 3.62 - 6.43	7.47 5.29 - 9.65	9.91 7.13 - 12.70
40–59	315	6.35	7.68 6.31 - 9.05	5.51 4.49 - 6.76	1.82 <LOD - 2.93	3.25 2.49 - 4.01	5.44 3.97 - 6.92	10.22 7.93 - 12.51	14.37 12.27 - 16.47	20.29 14.58 - 25.99
60–79	265	0.00	13.92 10.97 - 16.86	10.55 8.72 - 12.77	4.27 3.35 - 5.20	6.24 5.01 - 7.47	10.72 8.18 - 13.26	16.19 11.91 - 20.47	25.40 16.27 - 34.52	35.72 24.47 - 46.97

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.9 2,2',3,3',4,4'-Hexachlorobiphenyl (PCB 128)

Table 8.3.9a

2,2',3,3',4,4'-Hexachlorobiphenyl (PCB 128) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	98.74	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	526	99.62	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	596	98.15	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	544	98.53	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	801	98.25	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	99.58	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	97.86	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	97.50	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	865	99.19	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	286	99.65	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	315	98.41	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	264	99.62	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.9b

2,2',3,3',4,4'-Hexachlorobiphenyl (PCB 128) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1664	98.86	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	525	99.81	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	596	98.15	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	543	98.71	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	801	98.25	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	99.58	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	97.86	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	97.50	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	863	99.42	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	285	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	315	98.41	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	263	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.10 2,2',3,4,4',5'-Hexachlorobiphenyl (PCB 138)

Table 8.3.10a

2,2',3,4,4',5'-Hexachlorobiphenyl (PCB 138) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	1.44	0.09 0.08 - 0.11	0.06 0.05 - 0.07	0.02 0.01 - 0.02	0.03 0.03 - 0.04	0.06 0.05 - 0.07	0.12 0.10 - 0.13	0.21 0.18 - 0.25	0.28 0.23 - 0.32
20–39	526	3.99	0.04 0.03 - 0.04	0.03 0.02 - 0.04	0.01 0.01 - 0.02	0.02 0.02 - 0.02	0.03 0.02 - 0.04	0.05 0.04 - 0.05	0.07 0.04 - 0.09	0.10 0.08 - 0.12
40–59	596	0.34	0.10 0.09 - 0.12	0.08 0.07 - 0.09	0.03 0.03 - 0.04	0.05 0.04 - 0.05	0.07 0.06 - 0.09	0.12 0.10 - 0.14	0.20 0.16 - 0.24	0.25 0.20 - 0.30
60–79	546	0.18	0.18 0.15 - 0.21	0.14 0.12 - 0.16	0.06 0.05 - 0.07	0.09 0.07 - 0.10	0.14 0.11 - 0.16	0.23 0.20 - 0.26	0.34 0.29 - 0.39	0.40 0.33 - 0.47
Males										
Total, age 20–79	801	1.25	0.09 0.08 - 0.11	0.06 0.05 - 0.07	0.02 0.01 - 0.02	0.03 0.02 - 0.04	0.06 0.05 - 0.07	0.11 0.09 - 0.12	0.20 0.14 - 0.26	0.27 0.20 - 0.34
20–39	240	4.17	0.04 0.03 - 0.04	0.03 0.02 - 0.04	0.01 0.01 - 0.02	0.02 0.01 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.05	0.07 0.04 - 0.10	0.10 0.07 - 0.13
40–59	281	0.00	0.09 0.08 - 0.11	0.07 0.06 - 0.08	0.03 0.02 - 0.04	0.05 0.04 - 0.05	0.07 0.06 - 0.08	0.11 0.09 - 0.13	0.18 0.14 - 0.23	0.24 0.18 - 0.31
60–79	280	0.00	0.19 0.15 - 0.23	0.14 0.12 - 0.17	0.06 0.05 - 0.07	0.09 0.08 - 0.10	0.13 0.10 - 0.16	0.24 0.19 - 0.30	0.36 0.29 - 0.43	0.44 0.27 - 0.62
Females										
Total, age 20–79	867	1.61	0.10 0.08 - 0.11	0.06 0.05 - 0.07	0.02 0.01 - 0.02	0.03 0.03 - 0.04	0.06 0.05 - 0.07	0.13 0.11 - 0.15	0.22 0.19 - 0.24	0.28 0.24 - 0.32
20–39	286	3.85	0.04 0.03 - 0.05	0.03 0.02 - 0.04	0.01 <LOD - 0.02	0.02 0.01 - 0.02	0.03 0.02 - 0.04	0.05 0.04 - 0.06	0.06 0.03 - 0.09	0.10 0.06 - 0.13
40–59	315	0.63	0.11 0.09 - 0.13	0.08 0.07 - 0.09	0.03 0.03 - 0.04	0.05 0.04 - 0.06	0.09 0.07 - 0.10	0.13 0.12 - 0.15	0.21 0.17 - 0.26	0.27 0.19 - 0.34
60–79	266	0.38	0.17 0.15 - 0.19	0.13 0.11 - 0.16	0.06 0.04 - 0.07	0.08 0.06 - 0.11	0.15 0.12 - 0.18	0.23 0.20 - 0.25	0.30 0.26 - 0.34	0.37 0.32 - 0.43

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.10b

2,2',3,4,4',5'-Hexachlorobiphenyl (PCB 138) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	1.44	15.11 13.06 - 17.17	10.13 8.92 - 11.51	3.16 2.73 - 3.59	5.55 4.82 - 6.28	10.04 8.95 - 11.12	18.52 15.77 - 21.26	32.45 26.13 - 38.76	44.79 40.42 - 49.17
20–39	525	4.00	6.72 5.49 - 7.95	5.26 4.43 - 6.24	2.34 1.80 - 2.88	3.21 2.78 - 3.64	5.40 4.48 - 6.32	8.02 6.41 - 9.64	12.45 8.62 - 16.29	17.11 11.71 - 22.51
40–59	596	0.34	16.37 13.88 - 18.87	12.54 11.05 - 14.24	5.26 4.24 - 6.29	8.20 7.09 - 9.32	11.69 10.35 - 13.04	19.14 15.05 - 23.23	30.62 23.11 - 38.12	44.35 35.22 - 53.48
60–79	545	0.18	27.66 23.43 - 31.90	21.55 18.33 - 25.34	9.03 7.79 - 10.28	14.13 11.91 - 16.34	21.63 17.77 - 25.48	35.19 29.37 - 41.01	47.82 38.87 - 56.76	66.71 49.84 - 83.59
Males										
Total, age 20–79	801	1.25	14.79 12.34 - 17.23	9.75 8.44 - 11.27	3.17 2.60 - 3.73	5.26 4.33 - 6.20	9.42 7.66 - 11.19	17.20 13.94 - 20.46	30.05 20.71 - 39.39	45.27 36.91 - 53.63
20–39	240	4.17	6.47 4.96 - 7.99	5.07 4.11 - 6.26	2.40 1.82 - 2.98	3.16 2.51 - 3.82	4.72 3.63 - 5.82	7.50 5.57 - 9.42	13.91 8.46 - 19.36	16.89 8.00 - 25.77
40–59	281	0.00	15.30 12.56 - 18.04	11.86 10.22 - 13.76	5.25 4.25 - 6.25	7.39 6.27 - 8.51	11.13 9.91 - 12.36	17.09 12.74 - 21.44	28.70 19.46 - 37.94	40.21 27.80 - 52.63
60–79	280	0.00	29.62 23.71 - 35.53	22.80 19.45 - 26.73	9.31 7.71 - 10.91	14.94 12.89 - 16.99	21.31 18.00 - 24.62	36.21 26.35 - 46.06	56.78 40.11 - 73.45	77.79 54.99 - 100.60
Females										
Total, age 20–79	865	1.62	15.44 13.26 - 17.63	10.53 9.21 - 12.05	3.16 2.58 - 3.74	5.97 5.20 - 6.75	10.35 9.11 - 11.60	19.04 15.21 - 22.87	33.13 26.26 - 40.00	44.54 38.69 - 50.39
20–39	285	3.86	6.98 5.46 - 8.50	5.46 4.40 - 6.78	2.28 <LOD - 3.16	3.29 2.71 - 3.88	5.81 4.90 - 6.72	8.30 6.25 - 10.34	11.93 7.71 - 16.14	16.41 10.41 - 22.41
40–59	315	0.63	17.44 14.36 - 20.52	13.26 11.53 - 15.26	5.31 4.09 - 6.52	9.03 8.24 - 9.82	13.11 10.80 - 15.41	20.72 15.16 - 26.28	32.63 20.27 - 45.00	44.86 33.23 - 56.50
60–79	265	0.38	25.85 21.94 - 29.75	20.46 16.77 - 24.95	8.80 6.28 - 11.33	13.38 10.70 - 16.05	22.52 17.16 - 27.87	34.65 28.89 - 40.42	44.80 41.10 - 48.51	55.38 40.28 - 70.47

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.11 2,2',3,4',5,5'-Hexachlorobiphenyl (PCB 146)

Table 8.3.11a

2,2',3,4',5,5'-Hexachlorobiphenyl (PCB 146) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	37.11	0.02 0.02 - 0.02	0.01 0.01 - 0.01	<LOD	<LOD	0.01 0.01 - 0.01	0.02 0.02 - 0.02	0.04 0.03 - 0.05	0.06 0.04 - 0.08
20–39	526	81.94	—	—	<LOD	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.02 0.01 - 0.03
40–59	596	29.36	0.02 0.02 - 0.02	0.01 0.01 - 0.02	<LOD	<LOD	0.01 0.01 - 0.02	0.02 0.02 - 0.03	0.04 0.02 - 0.05	0.05 0.03 - 0.08
60–79	546	2.38	0.04 0.03 - 0.04	0.03 0.02 - 0.03	0.01 0.01 - 0.01	0.02 0.01 - 0.02	0.03 0.02 - 0.03	0.05 0.04 - 0.05	0.07 0.05 - 0.09	0.10 0.07 - 0.13
Males										
Total, age 20–79	801	35.33	0.02 0.01 - 0.02	0.01 0.01 - 0.01	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.02 - 0.02	0.04 0.03 - 0.06	0.06 0.04 - 0.09
20–39	240	81.67	—	—	<LOD	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.02 0.01 - 0.03
40–59	281	28.83	0.02 0.01 - 0.02	0.01 0.01 - 0.02	<LOD	<LOD	0.01 0.01 - 0.02	0.02 0.02 - 0.02	0.03 0.01 - 0.05	0.05 0.03 - 0.08
60–79	280	2.14	0.04 0.03 - 0.05	0.03 0.02 - 0.04	0.01 0.01 - 0.01	0.02 0.02 - 0.02	0.03 0.02 - 0.04	0.05 0.03 - 0.06	0.08 0.05 - 0.10	0.11 0.07 - 0.15
Females										
Total, age 20–79	867	38.75	0.02 0.02 - 0.02	0.01 0.01 - 0.01	<LOD	<LOD	0.01 0.01 - 0.01	0.02 0.02 - 0.03	0.04 0.03 - 0.05	0.05 0.04 - 0.07
20–39	286	82.17	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.02	0.02 0.01 - 0.02
40–59	315	29.84	0.02 0.02 - 0.02	0.01 0.01 - 0.02	<LOD	0.01 <LOD - 0.01	0.01 0.01 - 0.02	0.02 0.02 - 0.03	0.04 0.02 - 0.05	0.05 0.02 - 0.08
60–79	266	2.63	0.03 0.03 - 0.04	0.03 0.02 - 0.03	0.01 <LOD - 0.01	0.02 0.01 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.05	0.06 0.05 - 0.08	0.09 0.06 - 0.12

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.11b

2,2',3,4',5,5'-Hexachlorobiphenyl (PCB 146) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	37.15	3.04 2.48 - 3.60	2.02 1.76 - 2.32	<LOD	<LOD	2.02 1.68 - 2.36	3.53 2.91 - 4.15	6.38 4.56 - 8.20	9.19 6.31 - 12.08
20–39	525	82.10	—	—	<LOD	<LOD	<LOD	<LOD	2.69 1.79 - 3.59	3.87 2.28 - 5.46
40–59	596	29.36	3.15 2.42 - 3.89	2.29 1.92 - 2.73	<LOD	<LOD	2.29 1.99 - 2.60	3.44 2.72 - 4.16	5.73 3.14 - 8.31	8.60 3.61 - 13.58
60–79	545	2.39	5.82 4.66 - 6.99	4.44 3.71 - 5.32	1.94 1.61 - 2.26	2.85 2.36 - 3.35	4.28 3.45 - 5.10	6.93 5.12 - 8.74	10.59 7.39 - 13.79	16.08 11.56 - 20.60
Males										
Total, age 20–79	801	35.33	3.12 2.45 - 3.79	1.99 1.70 - 2.33	<LOD	<LOD	2.00 <LOD - 2.46	3.45 2.75 - 4.16	6.25 3.69 - 8.82	10.35 6.19 - 14.51
20–39	240	81.67	—	—	<LOD	<LOD	<LOD	<LOD	2.54 1.87 - 3.21	2.88 <LOD - 6.00
40–59	281	28.83	3.13 2.23 - 4.03	2.20 1.78 - 2.72	<LOD	<LOD	2.22 1.85 - 2.60	3.30 2.59 - 4.00	5.10 1.30 - 8.89	10.49 4.25 - 16.74
60–79	280	2.14	6.50 4.95 - 8.04	4.88 3.97 - 5.99	2.12 1.72 - 2.51	3.17 2.67 - 3.66	4.52 3.39 - 5.65	7.52 5.25 - 9.79	12.11 7.16 - 17.07	16.12 11.50 - 20.73
Females										
Total, age 20–79	865	38.84	2.96 2.45 - 3.47	2.05 1.79 - 2.35	<LOD	<LOD	2.03 1.70 - 2.36	3.63 2.95 - 4.30	6.53 4.79 - 8.28	8.55 6.53 - 10.57
20–39	285	82.46	—	—	<LOD	<LOD	<LOD	<LOD	2.93 <LOD - 4.67	3.94 2.23 - 5.66
40–59	315	29.84	3.17 2.46 - 3.89	2.38 2.02 - 2.79	<LOD	1.61 <LOD - 2.27	2.33 2.03 - 2.64	3.59 2.41 - 4.77	6.82 4.44 - 9.19	8.01 4.51 - 11.52
60–79	265	2.64	5.20 4.19 - 6.22	4.07 3.37 - 4.92	1.86 <LOD - 2.36	2.66 2.14 - 3.17	4.06 3.36 - 4.76	6.42 4.76 - 8.08	9.60 7.43 - 11.77	13.14 8.23 - 18.06

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.12 2,2',4,4',5,5'-Hexachlorobiphenyl (PCB 153)

Table 8.3.12a

2,2',4,4',5,5'-Hexachlorobiphenyl (PCB 153) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	2.52	0.18 0.15 - 0.20	0.11 0.09 - 0.13	0.03 0.02 - 0.04	0.06 0.05 - 0.06	0.12 0.11 - 0.13	0.22 0.19 - 0.25	0.39 0.32 - 0.45	0.54 0.42 - 0.66
20–39	526	7.60	0.07 0.05 - 0.08	0.05 0.04 - 0.06	0.02 0.02 - 0.03	0.03 0.03 - 0.04	0.05 0.04 - 0.06	0.08 0.06 - 0.10	0.13 0.09 - 0.17	0.17 0.13 - 0.22
40–59	596	0.34	0.19 0.16 - 0.22	0.15 0.13 - 0.17	0.07 0.06 - 0.07	0.10 0.09 - 0.11	0.14 0.13 - 0.16	0.22 0.19 - 0.26	0.33 0.26 - 0.41	0.47 0.29 - 0.65
60–79	546	0.00	0.35 0.30 - 0.39	0.28 0.25 - 0.32	0.13 0.10 - 0.15	0.18 0.16 - 0.21	0.28 0.23 - 0.32	0.43 0.37 - 0.49	0.61 0.48 - 0.75	0.81 0.65 - 0.98
Males										
Total, age 20–79	801	2.00	0.18 0.15 - 0.21	0.11 0.09 - 0.13	0.03 0.02 - 0.04	0.05 0.05 - 0.06	0.11 0.10 - 0.13	0.20 0.17 - 0.23	0.39 0.30 - 0.49	0.54 0.33 - 0.75
20–39	240	6.67	0.07 0.05 - 0.08	0.05 0.04 - 0.06	0.02 0.02 - 0.03	0.03 0.02 - 0.04	0.05 0.04 - 0.06	0.07 0.05 - 0.10	0.14 0.09 - 0.19	0.17 0.13 - 0.21
40–59	281	0.00	0.18 0.14 - 0.22	0.14 0.13 - 0.17	0.07 0.05 - 0.08	0.10 0.08 - 0.12	0.13 0.11 - 0.15	0.20 0.17 - 0.24	0.32 0.17 - 0.47	0.47 0.26 - 0.69
60–79	280	0.00	0.37 0.31 - 0.43	0.30 0.26 - 0.34	0.14 0.12 - 0.16	0.18 0.16 - 0.20	0.29 0.23 - 0.35	0.44 0.36 - 0.52	0.72 0.51 - 0.94	0.86 0.64 - 1.08
Females										
Total, age 20–79	867	3.00	0.18 0.15 - 0.20	0.11 0.09 - 0.13	0.03 0.02 - 0.04	0.06 0.04 - 0.07	0.13 0.11 - 0.14	0.24 0.20 - 0.27	0.38 0.32 - 0.45	0.51 0.42 - 0.60
20–39	286	8.39	0.07 0.05 - 0.08	0.04 0.03 - 0.06	<LOD	0.03 0.02 - 0.04	0.05 0.04 - 0.06	0.08 0.06 - 0.10	0.12 0.07 - 0.17	0.19 0.10 - 0.27
40–59	315	0.63	0.20 0.17 - 0.22	0.15 0.13 - 0.17	0.07 0.06 - 0.07	0.11 0.10 - 0.12	0.15 0.12 - 0.18	0.24 0.20 - 0.29	0.33 0.26 - 0.41	0.47 0.33 - 0.61
60–79	266	0.00	0.33 0.28 - 0.37	0.27 0.23 - 0.31	0.12 0.09 - 0.15	0.18 0.14 - 0.23	0.27 0.23 - 0.31	0.41 0.35 - 0.48	0.57 0.50 - 0.65	0.69 0.51 - 0.87

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.12b

2,2',4,4',5,5'-Hexachlorobiphenyl (PCB 153) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (μg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	2.52	28.62 24.27 - 32.97	18.31 15.83 - 21.16	5.46 4.40 - 6.53	9.72 8.53 - 10.90	19.46 17.05 - 21.88	36.09 31.28 - 40.90	61.13 47.50 - 74.75	85.64 67.71 - 103.57
20–39	525	7.62	11.93 8.98 - 14.88	8.27 6.49 - 10.56	3.74 <LOD - 7.61	5.64 4.65 - 6.63	8.82 7.27 - 10.37	14.48 10.32 - 18.64	22.71 14.64 - 30.78	31.96 20.15 - 43.76
40–59	596	0.34	30.78 25.40 - 36.15	24.13 21.38 - 27.23	10.86 9.53 - 12.20	16.54 15.27 - 17.80	23.43 20.72 - 26.15	35.13 28.33 - 41.94	54.11 36.87 - 71.34	83.97 47.25 - 120.68
60–79	545	0.00	54.24 46.65 - 61.83	44.00 38.55 - 50.24	20.34 18.00 - 22.68	28.89 24.58 - 33.21	43.43 37.37 - 49.48	65.67 53.61 - 77.73	99.48 79.30 - 119.67	132.34 95.44 - 169.24
Males										
Total, age 20–79	801	2.00	28.76 23.59 - 33.93	18.15 15.67 - 21.03	6.06 4.99 - 7.14	9.31 7.58 - 11.05	18.62 16.09 - 21.14	34.37 28.07 - 40.66	60.50 41.64 - 79.36	95.19 60.07 - 130.32
20–39	240	6.67	11.61 8.38 - 14.83	8.33 6.44 - 10.77	4.29 2.12 - 6.46	5.87 4.82 - 6.93	8.22 6.37 - 10.07	12.73 7.85 - 17.61	22.57 14.71 - 30..44	31.48 17.59 - 45.38
40–59	281	0.00	30.16 22.98 - 37.35	23.54 20.33 - 27.27	10.92 9.40 - 12.43	15.76 14.10 - 17.42	22.06 19.29 - 24.83	30.74 23.99 - 37.49	48.77 16.68 - 80.87	83.51 26.49 - 140.54
60–79	280	0.00	58.69 49.06 - 68.32	47.28 41.20 - 54.25	21.43 17.82 - 25.04	29.04 23.26 - 34.82	45.19 38.65 - 51.74	72.05 56.23 - 87.87	109.56 77.18 - 141.95	149.57 108.00 - 191.13
Females										
Total, age 20–79	865	3.01	28.48 24.38 - 32.58	18.46 15.61 - 21.83	5.01 3.67 - 6.35	10.05 8.54 - 11.57	20.68 17.59 - 23.77	36.64 31.58 - 41.69	61.22 47.63 - 74.80	82.74 68.65 - 96.83
20–39	285	8.42	12.28 8.61 - 15.94	8.22 5.90 - 11.44	<LOD	5.34 3.86 - 6.82	9.43 7.58 - 11.28	14.62 10.54 - 18.71	23.81 12.38 - 35.24	34.01 17.71 - 50.31
40–59	315	0.63	31.39 26.30 - 36.48	24.73 21.68 - 28.21	10.11 8.04 - 12.17	17.18 15.52 - 18.85	24.61 20.65 - 28.57	38.35 29.86 - 46.84	60.19 40.95 - 79.42	81.96 57.36 - 106.55
60–79	265	0.00	50.12 42.99 - 57.25	41.17 35.48 - 47.78	19.32 15.63 - 23.01	28.78 23.03 - 34.54	41.25 34.29 - 48.20	61.37 49.01 - 73.74	85.83 71.15 - 100.52	106.38 80.36 - 132.40

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.13 2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)

Table 8.3.13a

2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	28.78	0.02 0.02 - 0.03	0.02 0.01 - 0.02	<LOD	<LOD	0.02 0.02 - 0.02	0.03 0.03 - 0.04	0.05 0.05 - 0.06	0.07 0.06 - 0.09
20–39	526	77.57	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.02	0.02 0.02 - 0.03
40–59	596	11.74	0.03 0.02 - 0.03	0.02 0.02 - 0.02	<LOD <LOD - 0.01	0.01 0.01 - 0.02	0.02 0.02 - 0.02	0.03 0.03 - 0.04	0.05 0.04 - 0.05	0.06 0.02 - 0.09
60–79	546	0.37	0.05 0.04 - 0.06	0.04 0.04 - 0.05	0.02 0.02 - 0.02	0.03 0.02 - 0.03	0.04 0.04 - 0.05	0.06 0.05 - 0.07	0.09 0.07 - 0.10	0.11 0.09 - 0.13
Males										
Total, age 20–79	801	26.22	0.02 0.02 - 0.03	0.02 0.01 - 0.02	<LOD	<LOD	0.02 0.01 - 0.02	0.03 0.03 - 0.03	0.05 0.05 - 0.06	0.07 0.04 - 0.10
20–39	240	76.67	—	—	<LOD	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.02 0.01 - 0.03
40–59	281	9.25	0.03 0.02 - 0.03	0.02 0.02 - 0.02	<LOD <LOD - 0.01	0.01 0.01 - 0.02	0.02 0.02 - 0.02	0.03 0.03 - 0.04	0.05 0.03 - 0.06	0.06 <LOD - 0.12
60–79	280	0.00	0.05 0.04 - 0.06	0.04 0.04 - 0.05	0.02 0.02 - 0.02	0.03 0.02 - 0.03	0.04 0.04 - 0.05	0.06 0.05 - 0.08	0.10 0.08 - 0.12	0.12 0.09 - 0.15
Females										
Total, age 20–79	867	31.14	0.03 0.02 - 0.03	0.02 0.01 - 0.02	<LOD	<LOD	0.02 0.02 - 0.02	0.03 0.03 - 0.04	0.05 0.05 - 0.06	0.07 0.06 - 0.08
20–39	286	78.32	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.02	0.02 0.01 - 0.04
40–59	315	13.97	0.03 0.02 - 0.03	0.02 0.02 - 0.02	<LOD <LOD - 0.01	0.02 0.01 - 0.02	0.02 0.02 - 0.03	0.03 0.03 - 0.04	0.04 0.04 - 0.05	0.06 0.03 - 0.08
60–79	266	0.75	0.05 0.04 - 0.05	0.04 0.04 - 0.04	0.02 0.02 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.05	0.06 0.05 - 0.07	0.08 0.07 - 0.09	0.10 0.09 - 0.12

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.13b

2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	28.81	4.03 3.49 - 4.57	2.64 2.40 - 2.92	<LOD	<LOD	2.78 2.45 - 3.11	5.20 4.59 - 5.81	8.61 7.29 - 9.93	11.08 8.37 - 13.79
20–39	525	77.71	—	—	<LOD	<LOD	<LOD	<LOD	2.63 <LOD - 3.51	3.75 2.60 - 4.90
40–59	596	11.74	4.44 3.66 - 5.23	3.50 3.09 - 3.96	<LOD <LOD - 2.06	2.34 2.05 - 2.63	3.60 3.24 - 3.97	5.16 4.48 - 5.83	7.73 5.89 - 9.57	10.45 5.25 - 15.66
60–79	545	0.37	7.82 6.93 - 8.71	6.47 5.84 - 7.17	3.20 2.92 - 3.48	4.35 3.82 - 4.89	6.66 5.77 - 7.55	9.30 8.03 - 10.57	13.46 11.57 - 15.36	17.49 12.94 - 22.05
Males										
Total, age 20–79	801	26.22	4.03 3.34 - 4.71	2.58 2.29 - 2.90	<LOD	<LOD	2.58 2.21 - 2.95	5.09 4.37 - 5.81	8.33 6.79 - 9.87	12.02 6.72 - 17.31
20–39	240	76.67	—	—	<LOD	<LOD	<LOD	<LOD	2.50 1.58 - 3.42	3.36 2.40 - 4.32
40–59	281	9.25	4.37 3.28 - 5.46	3.42 2.92 - 4.01	<LOD <LOD - 1.88	2.28 1.99 - 2.57	3.45 2.92 - 3.98	5.16 4.18 - 6.14	7.60 4.92 - 10.28	10.51 <LOD - 19.21
60–79	280	0.00	8.45 7.19 - 9.71	6.99 6.21 - 7.88	3.27 2.80 - 3.74	4.58 3.97 - 5.20	7.28 6.41 - 8.15	10.08 8.30 - 11.85	15.86 11.38 - 20.34	21.32 15.18 - 27.46
Females										
Total, age 20–79	865	31.21	4.04 3.57 - 4.52	2.71 2.47 - 2.99	<LOD	<LOD	2.96 2.54 - 3.37	5.24 4.54 - 5.94	8.91 7.57 - 10.25	10.58 8.70 - 12.46
20–39	285	78.60	—	—	<LOD	<LOD	<LOD	<LOD	2.66 <LOD - 3.92	4.90 1.94 - 7.86
40–59	315	13.97	4.52 3.83 - 5.21	3.58 3.16 - 4.04	<LOD <LOD - 2.16	2.48 2.11 - 2.86	3.82 3.45 - 4.19	5.15 4.40 - 5.91	8.71 5.97 - 11.44	10.40 7.34 - 13.46
60–79	265	0.75	7.23 6.40 - 8.07	6.02 5.34 - 6.78	3.04 2.65 - 3.42	4.32 3.80 - 4.85	6.12 5.29 - 6.95	8.68 7.19 - 10.16	12.54 10.67 - 14.42	15.30 13.38 - 17.23

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.14 2,3,3',4',5,6-Hexachlorobiphenyl (PCB 163)

Table 8.3.14a

2,3,3',4',5,6-Hexachlorobiphenyl (PCB 163)– Arithmetic and geometric means, and selected percentiles of plasma concentrations (μg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	21.34	0.03 0.03 - 0.04	0.02 0.02 - 0.02	<LOD	<LOD <LOD - 0.01	0.02 0.02 - 0.02	0.04 0.03 - 0.04	0.07 0.05 - 0.08	0.10 0.07 - 0.12
20–39	526	59.32	—	—	<LOD	<LOD	<LOD	0.01 <LOD - 0.02	0.02 0.01 - 0.03	0.03 0.02 - 0.04
40–59	596	7.38	0.03 0.03 - 0.04	0.03 0.02 - 0.03	0.01 <LOD - 0.01	0.02 0.01 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.04	0.06 0.04 - 0.07	0.08 0.04 - 0.12
60–79	546	0.00	0.06 0.05 - 0.07	0.05 0.04 - 0.06	0.02 0.02 - 0.02	0.03 0.03 - 0.04	0.05 0.04 - 0.06	0.08 0.06 - 0.09	0.12 0.09 - 0.15	0.16 0.13 - 0.18
Males										
Total, age 20–79	801	19.35	0.03 0.02 - 0.04	0.02 0.02 - 0.02	<LOD	<LOD	0.02 0.02 - 0.02	0.04 0.03 - 0.04	0.07 0.05 - 0.08	0.10 0.05 - 0.14
20–39	240	57.92	—	—	<LOD	<LOD	<LOD	0.01 <LOD - 0.02	0.02 0.01 - 0.03	0.03 0.02 - 0.04
40–59	281	5.69	0.03 0.02 - 0.04	0.02 0.02 - 0.03	0.01 <LOD - 0.01	0.02 0.01 - 0.02	0.02 0.02 - 0.03	0.04 0.03 - 0.04	0.06 0.03 - 0.09	0.07 <LOD - 0.13
60–79	280	0.00	0.07 0.05 - 0.08	0.05 0.05 - 0.06	0.02 0.02 - 0.03	0.03 0.03 - 0.04	0.05 0.04 - 0.06	0.08 0.06 - 0.10	0.13 0.09 - 0.17	0.16 0.12 - 0.19
Females										
Total, age 20–79	867	23.18	0.03 0.03 - 0.04	0.02 0.02 - 0.02	<LOD	<LOD <LOD - 0.01	0.02 0.02 - 0.03	0.04 0.03 - 0.04	0.07 0.05 - 0.08	0.10 0.08 - 0.12
20–39	286	60.49	—	—	<LOD	<LOD	<LOD	0.01 <LOD - 0.02	0.02 0.01 - 0.03	0.03 0.02 - 0.04
40–59	315	8.89	0.03 0.03 - 0.04	0.03 0.02 - 0.03	0.01 <LOD - 0.01	0.02 0.01 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.04	0.06 0.04 - 0.08	0.09 0.06 - 0.12
60–79	266	0.00	0.06 0.05 - 0.07	0.05 0.04 - 0.06	0.02 0.02 - 0.03	0.03 0.03 - 0.04	0.05 0.04 - 0.06	0.07 0.06 - 0.09	0.11 0.08 - 0.14	0.14 0.11 - 0.18

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.14b

2,3,3',4',5,6-Hexachlorobiphenyl (PCB 163) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (μg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	21.37	5.03 4.17 - 5.89	3.22 2.85 - 3.65	<LOD	<LOD <LOD - 1.83	3.40 2.97 - 3.83	6.20 5.15 - 7.25	10.69 8.15 - 13.24	16.28 11.97 - 20.59
20–39	525	59.43	—	—	<LOD	<LOD	<LOD	2.33 <LOD - 3.07	3.92 2.35 - 5.50	5.60 3.81 - 7.40
40–59	596	7.38	5.32 4.18 - 6.45	4.10 3.54 - 4.75	1.92 <LOD - 2.15	2.74 2.33 - 3.15	4.10 3.60 - 4.61	5.75 4.34 - 7.16	8.99 5.53 - 12.45	13.84 6.62 - 21.06
60–79	545	0.00	9.95 8.36 - 11.53	7.96 6.92 - 9.15	3.68 3.27 - 4.08	5.15 4.48 - 5.82	7.64 6.66 - 8.62	11.79 8.94 - 14.64	18.50 14.98 - 22.03	24.99 19.52 - 30.47
Males										
Total, age 20–79	801	19.35	5.00 3.97 - 6.03	3.10 2.70 - 3.56	<LOD	<LOD	3.21 2.87 - 3.55	5.75 4.42 - 7.08	10.69 7.52 - 13.86	16.70 10.48 - 22.92
20–39	240	57.92	—	—	<LOD	<LOD	<LOD	2.09 <LOD - 2.89	3.29 1.46 - 5.12	5.50 3.32 - 7.67
40–59	281	5.69	5.17 3.66 - 6.67	3.91 3.25 - 4.71	1.85 <LOD - 2.25	2.53 1.98 - 3.08	3.89 3.40 - 4.38	5.39 3.92 - 6.85	8.66 3.49 - 13.83	15.36 <LOD - 25.85
60–79	280	0.00	10.63 8.63 - 12.63	8.44 7.26 - 9.81	3.52 3.02 - 4.03	5.25 4.23 - 6.27	8.13 7.14 - 9.11	12.62 8.87 - 16.37	19.81 14.21 - 25.41	26.57 19.18 - 33.96
Females										
Total, age 20–79	865	23.24	5.06 4.29 - 5.84	3.35 2.95 - 3.80	<LOD	<LOD <LOD - 2.17	3.67 2.99 - 4.34	6.35 5.28 - 7.42	10.56 8.00 - 13.12	15.83 11.39 - 20.26
20–39	285	60.70	—	—	<LOD	<LOD	<LOD	2.50 <LOD - 3.35	4.23 2.23 - 6.23	5.72 3.32 - 8.13
40–59	315	8.89	5.46 4.47 - 6.46	4.29 3.76 - 4.90	1.96 <LOD - 2.17	2.91 2.57 - 3.25	4.42 3.82 - 5.02	6.30 4.69 - 7.92	10.68 7.23 - 14.14	12.79 7.11 - 18.48
60–79	265	0.00	9.31 7.77 - 10.86	7.54 6.46 - 8.79	3.89 3.09 - 4.69	5.12 4.46 - 5.77	7.15 6.17 - 8.12	10.84 7.57 - 14.11	17.53 13.87 - 21.18	23.29 18.18 - 28.39

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.15 2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)

Table 8.3.15a

2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	75.48	—	—	<LOD	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.02 0.01 - 0.02
20–39	526	98.48	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	596	83.05	—	—	<LOD	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.02 <LOD - 0.02
60–79	546	45.05	—	—	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.01 - 0.02	0.02 0.02 - 0.03	0.03 0.03 - 0.04
Males										
Total, age 20–79	801	79.03	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.02	0.02 0.01 - 0.03
20–39	240	98.33	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	88.97	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.02	0.01 <LOD - 0.02
60–79	280	52.50	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.02 0.01 - 0.03	0.04 0.02 - 0.05
Females										
Total, age 20–79	867	72.20	—	—	<LOD	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.02 0.02 - 0.02
20–39	286	98.60	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	315	77.78	—	—	<LOD	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.02 0.01 - 0.02
60–79	266	37.22	0.01 0.01 - 0.02	0.01 <LOD - 0.01	<LOD	<LOD	0.01 0.01 - 0.01	0.02 0.02 - 0.02	0.03 0.02 - 0.03	0.03 0.02 - 0.04

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.15b

2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	75.57	—	—	<LOD	<LOD	<LOD	<LOD	2.21 1.76 - 2.67	3.38 2.49 - 4.27
20–39	525	98.67	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	596	83.05	—	—	<LOD	<LOD	<LOD	<LOD	1.96 1.38 - 2.54	3.13 <LOD - 4.62
60–79	545	45.14	—	—	<LOD	<LOD	1.59 <LOD - 2.07	2.48 2.10 - 2.86	3.93 3.04 - 4.81	5.49 4.01 - 6.97
Males										
Total, age 20–79	801	79.03	—	—	<LOD	<LOD	<LOD	<LOD	1.96 <LOD - 2.51	3.09 1.74 - 4.44
20–39	240	98.33	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	88.97	—	—	<LOD	<LOD	<LOD	<LOD	1.63 <LOD - 2.80	3.59 <LOD - 6.38
60–79	280	52.50	—	—	<LOD	<LOD	<LOD	2.35 1.93 - 2.77	3.86 1.91 - 5.82	5.62 3.12 - 8.12
Females										
Total, age 20–79	865	72.37	—	—	<LOD	<LOD	<LOD	<LOD	2.39 1.96 - 2.82	3.56 2.85 - 4.27
20–39	285	98.95	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	315	77.78	—	—	<LOD	<LOD	<LOD	<LOD	2.10 1.62 - 2.57	3.06 2.20 - 3.91
60–79	265	37.36	2.06 1.74 - 2.38	1.62 <LOD - 1.85	<LOD	<LOD	1.79 1.46 - 2.11	2.55 1.96 - 3.14	3.95 3.27 - 4.64	4.76 3.56 - 5.96

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.16 2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)

Table 8.3.16a

2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	14.87	0.05 0.04 - 0.05	0.03 0.02 - 0.03	<LOD	0.01 0.01 - 0.02	0.03 0.03 - 0.03	0.06 0.05 - 0.07	0.10 0.08 - 0.12	0.14 0.11 - 0.17
20–39	526	44.49	—	—	<LOD	<LOD	<LOD <LOD - 0.01	0.02 0.02 - 0.02	0.03 0.02 - 0.03	0.04 0.01 - 0.06
40–59	596	2.35	0.05 0.04 - 0.06	0.04 0.04 - 0.04	0.02 0.02 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.04	0.06 0.05 - 0.07	0.08 0.06 - 0.10	0.13 0.06 - 0.20
60–79	546	0.00	0.10 0.09 - 0.11	0.08 0.07 - 0.09	0.04 0.03 - 0.04	0.05 0.04 - 0.06	0.08 0.07 - 0.09	0.11 0.10 - 0.13	0.17 0.13 - 0.21	0.24 0.19 - 0.28
Males										
Total, age 20–79	801	11.74	0.05 0.04 - 0.06	0.03 0.03 - 0.03	<LOD	0.01 0.01 - 0.02	0.03 0.03 - 0.03	0.06 0.05 - 0.06	0.11 0.08 - 0.13	0.15 0.08 - 0.21
20–39	240	38.33	0.02 0.01 - 0.02	0.01 <LOD - 0.01	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.02 - 0.02	0.03 0.02 - 0.04	0.03 0.02 - 0.05
40–59	281	0.71	0.05 0.04 - 0.07	0.04 0.03 - 0.05	0.02 0.02 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.04	0.06 0.05 - 0.07	0.09 0.05 - 0.13	0.13 0.03 - 0.24
60–79	280	0.00	0.10 0.09 - 0.11	0.08 0.08 - 0.09	0.04 0.03 - 0.05	0.05 0.05 - 0.06	0.08 0.07 - 0.10	0.13 0.11 - 0.14	0.18 0.13 - 0.24	0.24 0.19 - 0.28
Females										
Total, age 20–79	867	17.76	0.05 0.04 - 0.05	0.03 0.02 - 0.03	<LOD	0.01 <LOD - 0.01	0.03 0.03 - 0.04	0.06 0.05 - 0.07	0.10 0.08 - 0.12	0.14 0.11 - 0.16
20–39	286	49.65	—	—	<LOD	<LOD	<LOD <LOD - 0.01	0.02 0.01 - 0.02	0.03 0.01 - 0.04	0.05 0.01 - 0.09
40–59	315	3.81	0.05 0.04 - 0.06	0.04 0.03 - 0.04	0.02 0.01 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.04	0.06 0.05 - 0.07	0.08 0.07 - 0.09	0.12 0.07 - 0.16
60–79	266	0.00	0.09 0.08 - 0.10	0.07 0.06 - 0.08	0.04 0.03 - 0.04	0.05 0.04 - 0.06	0.07 0.06 - 0.08	0.10 0.09 - 0.11	0.15 0.12 - 0.17	0.21 0.14 - 0.28

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.16b

2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	14.89	7.61 6.30 - 8.93	4.60 4.09 - 5.17	<LOD	2.21 1.86 - 2.56	4.97 4.42 - 5.52	9.57 8.13 - 11.01	15.90 13.19 - 18.62	23.22 17.83 - 28.60
20–39	525	44.57	—	—	<LOD	<LOD	<LOD <LOD - 2.13	2.90 2.51 - 3.29	4.67 3.02 - 6.32	7.22 3.04 - 11.40
40–59	596	2.35	8.34 6.45 - 10.22	6.40 5.63 - 7.27	3.05 2.70 - 3.40	4.16 3.64 - 4.68	6.14 5.48 - 6.80	9.40 7.84 - 10.96	15.09 11.31 - 18.87	20.37 7.39 - 33.36
60–79	545	0.00	14.90 13.15 - 16.65	12.03 10.94 - 13.24	5.72 4.75 - 6.69	7.93 6.82 - 9.04	11.80 10.38 - 13.22	17.28 14.60 - 19.96	26.59 21.87 - 31.32	37.71 24.41 - 51.01
Males										
Total, age 20–79	801	11.74	7.98 6.29 - 9.66	4.74 4.15 - 5.40	<LOD	2.38 1.94 - 2.82	4.95 4.30 - 5.60	9.54 7.98 - 11.11	16.53 11.57 - 21.50	25.03 15.18 - 34.88
20–39	240	38.33	2.68 1.99 - 3.38	1.90 <LOD - 2.27	<LOD	<LOD	1.71 <LOD - 2.22	3.00 2.40 - 3.60	4.85 3.08 - 6.61	6.68 4.78 - 8.59
40–59	281	0.71	8.74 5.86 - 11.62	6.65 5.63 - 7.86	3.23 2.80 - 3.65	4.21 3.60 - 4.82	6.02 5.34 - 6.71	9.44 7.52 - 11.36	15.21 8.63 - 21.80	23.32 8.77 - 37.87
60–79	280	0.00	16.53 14.14 - 18.93	13.48 11.93 - 15.23	6.12 4.91 - 7.33	8.74 7.17 - 10.32	13.26 11.20 - 15.32	20.48 16.61 - 24.35	28.19 18.46 - 37.91	45.60 27.26 - 63.94
Females										
Total, age 20–79	865	17.80	7.25 6.17 - 8.33	4.46 3.97 - 5.01	<LOD	2.11 <LOD - 2.57	5.00 4.38 - 5.61	9.57 7.88 - 11.25	15.73 13.09 - 18.38	20.67 15.12 - 26.21
20–39	285	49.82	—	—	<LOD	<LOD	<LOD <LOD - 2.04	2.79 2.31 - 3.28	4.01 0.74 - 7.27	10.39 1.27 - 19.52
40–59	315	3.81	7.93 6.57 - 9.29	6.15 5.46 - 6.93	2.70 2.08 - 3.31	4.05 3.48 - 4.62	6.26 5.30 - 7.23	9.12 7.26 - 10.98	14.41 10.96 - 17.86	18.52 11.05 - 25.98
60–79	265	0.00	13.39 11.84 - 14.93	10.83 9.67 - 12.13	5.54 4.41 - 6.66	7.66 6.54 - 8.77	10.97 9.94 - 12.00	15.69 13.88 - 17.51	21.82 18.59 - 25.05	32.13 21.51 - 42.75

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.17 2,2',3,3',5,5',6-Heptachlorobiphenyl (PCB 178)

Table 8.3.17a

2,2',3,3',5,5',6-Heptachlorobiphenyl (PCB 178) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	61.57	—	—	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.02 - 0.03	0.03 0.02 - 0.04
20–39	526	97.72	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	596	68.62	—	—	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.01 - 0.02	0.02 0.02 - 0.03
60–79	546	19.05	0.02 0.02 - 0.02	0.01 0.01 - 0.02	<LOD	<LOD <LOD - 0.01	0.02 0.01 - 0.02	0.02 0.02 - 0.03	0.04 0.03 - 0.05	0.05 0.04 - 0.06
Males										
Total, age 20–79	801	58.93	—	—	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.02 - 0.03	0.03 0.02 - 0.04
20–39	240	97.50	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	67.97	—	—	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.02 <LOD - 0.03	0.03 0.01 - 0.04
60–79	280	16.79	0.02 0.02 - 0.02	0.02 0.01 - 0.02	<LOD	0.01 <LOD - 0.01	0.02 0.01 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.05	0.05 0.04 - 0.06
Females										
Total, age 20–79	867	64.01	—	—	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.02 - 0.02	0.03 0.02 - 0.03
20–39	286	97.90	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	315	69.21	—	—	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.02 <LOD - 0.02	0.02 0.02 - 0.03
60–79	266	21.43	0.02 0.02 - 0.02	0.01 0.01 - 0.02	<LOD	<LOD <LOD - 0.01	0.01 0.01 - 0.02	0.02 0.02 - 0.03	0.03 0.02 - 0.04	0.05 0.03 - 0.06

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.17b

2,2',3,3',5,5',6-Heptachlorobiphenyl (PCB 178) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (μg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	61.64	—	—	<LOD	<LOD	<LOD	1.79 <LOD - 2.17	3.22 2.61 - 3.83	4.64 3.08 - 6.21
20–39	525	97.90	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	596	68.62	—	—	<LOD	<LOD	<LOD	1.71 <LOD - 2.20	2.99 2.26 - 3.71	3.93 1.58 - 6.29
60–79	545	19.08	3.09 2.69 - 3.50	2.32 2.03 - 2.67	<LOD	<LOD <LOD - 1.89	2.37 1.94 - 2.80	3.63 2.99 - 4.28	5.99 4.94 - 7.04	8.09 6.45 - 9.73
Males										
Total, age 20–79	801	58.93	—	—	<LOD	<LOD	<LOD	1.82 <LOD - 2.24	3.46 2.52 - 4.39	5.85 3.84 - 7.86
20–39	240	97.50	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	67.97	—	—	<LOD	<LOD	<LOD	1.81 <LOD - 2.35	3.10 <LOD - 4.48	4.18 0.97 - 7.38
60–79	280	16.79	3.48 2.99 - 3.97	2.60 2.22 - 3.04	<LOD	1.63 <LOD - 2.06	2.80 2.30 - 3.30	4.19 3.11 - 5.26	6.71 5.73 - 7.69	9.20 6.93 - 11.47
Females										
Total, age 20–79	865	64.16	—	—	<LOD	<LOD	<LOD	1.71 <LOD - 2.11	2.95 2.41 - 3.49	4.05 3.30 - 4.79
20–39	285	98.25	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	315	69.21	—	—	<LOD	<LOD	<LOD	1.58 <LOD - 2.19	2.79 <LOD - 3.48	3.61 2.58 - 4.63
60–79	265	21.51	2.73 2.27 - 3.19	2.10 1.80 - 2.45	<LOD	<LOD <LOD - 1.92	2.10 1.76 - 2.44	3.16 2.45 - 3.87	4.62 3.55 - 5.68	6.78 4.77 - 8.78

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.18 2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)

Table 8.3.18a

2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	1.38	0.16 0.14 - 0.18	0.09 0.08 - 0.10	0.02 0.02 - 0.02	0.04 0.03 - 0.05	0.10 0.09 - 0.11	0.20 0.18 - 0.22	0.35 0.28 - 0.41	0.49 0.38 - 0.60
20–39	526	4.18	0.05 0.04 - 0.06	0.03 0.03 - 0.04	0.01 0.01 - 0.02	0.02 0.02 - 0.02	0.03 0.03 - 0.04	0.06 0.05 - 0.07	0.09 0.06 - 0.11	0.13 0.06 - 0.19
40–59	596	0.17	0.17 0.14 - 0.20	0.13 0.12 - 0.15	0.06 0.05 - 0.06	0.09 0.08 - 0.10	0.13 0.11 - 0.14	0.19 0.17 - 0.22	0.28 0.21 - 0.34	0.39 0.16 - 0.63
60–79	546	0.00	0.33 0.29 - 0.36	0.27 0.24 - 0.29	0.13 0.11 - 0.14	0.18 0.16 - 0.20	0.26 0.23 - 0.29	0.39 0.34 - 0.45	0.58 0.45 - 0.72	0.82 0.66 - 0.98
Males										
Total, age 20–79	801	1.12	0.17 0.14 - 0.19	0.10 0.08 - 0.11	0.02 0.02 - 0.03	0.05 0.04 - 0.05	0.10 0.09 - 0.11	0.20 0.18 - 0.22	0.38 0.30 - 0.47	0.53 0.32 - 0.73
20–39	240	3.75	0.05 0.04 - 0.06	0.04 0.03 - 0.04	0.01 0.01 - 0.02	0.02 0.02 - 0.03	0.04 0.03 - 0.04	0.06 0.05 - 0.07	0.09 0.07 - 0.11	0.10 0.05 - 0.16
40–59	281	0.00	0.18 0.12 - 0.23	0.14 0.12 - 0.16	0.06 0.05 - 0.07	0.09 0.08 - 0.10	0.13 0.11 - 0.15	0.20 0.17 - 0.22	0.30 0.17 - 0.44	0.41 0.05 - 0.78
60–79	280	0.00	0.36 0.32 - 0.40	0.29 0.27 - 0.33	0.13 0.11 - 0.15	0.18 0.16 - 0.21	0.29 0.26 - 0.32	0.45 0.39 - 0.51	0.70 0.54 - 0.86	0.83 0.69 - 0.98
Females										
Total, age 20–79	867	1.61	0.15 0.13 - 0.17	0.09 0.08 - 0.10	0.02 0.01 - 0.02	0.04 0.03 - 0.05	0.10 0.09 - 0.12	0.20 0.17 - 0.22	0.33 0.27 - 0.39	0.45 0.35 - 0.56
20–39	286	4.55	0.05 0.03 - 0.07	0.03 0.03 - 0.04	0.01 <LOD - 0.02	0.02 0.01 - 0.02	0.03 0.02 - 0.04	0.05 0.04 - 0.06	0.09 0.04 - 0.13	0.15 0.05 - 0.25
40–59	315	0.32	0.16 0.14 - 0.19	0.13 0.11 - 0.14	0.06 0.05 - 0.07	0.09 0.08 - 0.10	0.13 0.11 - 0.15	0.19 0.15 - 0.22	0.26 0.21 - 0.30	0.36 0.22 - 0.51
60–79	266	0.00	0.30 0.26 - 0.34	0.24 0.21 - 0.27	0.12 0.08 - 0.15	0.17 0.14 - 0.20	0.24 0.22 - 0.27	0.35 0.32 - 0.37	0.52 0.41 - 0.63	0.75 0.44 - 1.07

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.18b

2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	1.38	25.74 21.38 - 30.10	15.21 13.52 - 17.11	3.71 3.07 - 4.35	7.32 6.37 - 8.26	16.48 14.90 - 18.06	31.84 27.01 - 36.68	54.26 43.89 - 64.63	77.33 58.83 - 95.83
20–39	525	4.19	9.06 6.49 - 11.63	6.05 5.07 - 7.22	2.31 1.86 - 2.76	3.78 3.20 - 4.35	6.22 5.13 - 7.32	9.77 8.17 - 11.37	14.89 9.93 - 19.86	21.31 8.99 - 33.63
40–59	596	0.17	27.69 21.55 - 33.84	21.20 18.68 - 24.06	9.83 8.64 - 11.02	13.91 12.42 - 15.39	20.49 18.06 - 22.92	30.21 24.58 - 35.83	49.28 36.51 - 62.05	72.48 31.16 - 113.80
60–79	545	0.00	51.76 45.33 - 58.19	41.27 37.52 - 45.39	19.31 15.91 - 22.70	27.21 23.36 - 31.06	41.23 36.51 - 45.95	59.95 51.22 - 68.68	90.01 66.34 - 113.67	130.05 93.20 - 166.89
Males										
Total, age 20–79	801	1.12	27.20 21.67 - 32.72	15.85 13.98 - 17.97	4.15 3.41 - 4.90	7.51 6.29 - 8.74	16.50 14.83 - 18.18	31.76 24.58 - 38.94	58.99 41.89 - 76.09	83.54 42.39 - 124.69
20–39	240	3.75	8.83 6.52 - 11.14	6.30 5.17 - 7.68	2.60 1.98 - 3.22	3.97 3.23 - 4.72	6.41 5.15 - 7.68	10.02 7.92 - 12.13	15.60 10.69 - 20.51	21.17 14.87 - 27.48
40–59	281	0.00	29.39 19.93 - 38.85	22.13 18.68 - 26.22	10.15 8.55 - 11.74	14.54 12.52 - 16.57	19.95 17.64 - 22.26	30.78 22.30 - 39.25	52.50 28.86 - 76.13	74.72 <LOD - 150.25
60–79	280	0.00	57.84 49.01 - 66.66	46.74 41.25 - 52.97	21.86 17.30 - 26.42	29.59 23.97 - 35.21	47.02 39.95 - 54.09	70.71 59.34 - 82.07	109.98 73.07 - 146.90	145.53 102.40 - 188.67
Females										
Total, age 20–79	865	1.62	24.28 20.68 - 27.88	14.60 12.87 - 16.56	3.34 2.54 - 4.14	7.17 5.86 - 8.49	16.31 14.15 - 18.48	31.83 27.09 - 36.57	52.58 43.32 - 61.84	69.04 51.54 - 86.54
20–39	285	4.56	9.31 5.76 - 12.85	5.79 4.61 - 7.27	2.02 <LOD - 2.94	3.40 2.65 - 4.15	5.94 4.72 - 7.17	9.52 7.65 - 11.38	13.16 3.13 - 23.18	31.56 5.60 - 57.51
40–59	315	0.32	26.00 21.79 - 30.22	20.31 18.05 - 22.84	9.14 7.49 - 10.80	13.60 12.09 - 15.10	20.77 17.43 - 24.11	29.67 23.92 - 35.41	48.75 34.51 - 62.99	57.51 35.35 - 79.67
60–79	265	0.00	46.13 40.36 - 51.89	36.77 32.55 - 41.53	18.08 14.39 - 21.76	25.71 21.01 - 30.41	37.52 33.23 - 41.81	53.14 47.27 - 59.02	75.46 61.83 - 89.08	109.10 71.15 - 147.05

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.19 2,2',3,4,4',5',6-Heptachlorobiphenyl (PCB 183)

Table 8.3.19a

2,2',3,4,4',5',6-Heptachlorobiphenyl (PCB 183) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	48.92	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.05
20–39	526	91.06	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.02
40–59	596	46.31	—	—	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.01 - 0.02	0.03 0.02 - 0.04	0.04 0.03 - 0.05
60–79	546	11.17	0.03 0.02 - 0.03	0.02 0.02 - 0.02	<LOD	0.01 0.01 - 0.01	0.02 0.02 - 0.02	0.03 0.03 - 0.04	0.05 0.04 - 0.06	0.07 0.06 - 0.09
Males										
Total, age 20–79	801	48.69	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.03 0.02 - 0.04	0.04 0.03 - 0.05
20–39	240	92.08	—	—	<LOD	<LOD	<LOD	<LOD	<LOD <LOD - 0.02	0.01 <LOD - 0.02
40–59	281	49.11	—	—	<LOD	<LOD	<LOD <LOD - 0.01	0.02 0.01 - 0.02	0.02 0.01 - 0.04	0.04 0.03 - 0.06
60–79	280	11.07	0.03 0.02 - 0.03	0.02 0.02 - 0.02	<LOD <LOD - 0.01	0.01 0.01 - 0.01	0.02 0.02 - 0.02	0.03 0.03 - 0.04	0.06 0.03 - 0.08	0.08 0.07 - 0.10
Females										
Total, age 20–79	867	49.13	—	—	<LOD	<LOD	<LOD	0.02 0.02 - 0.02	0.03 0.03 - 0.03	0.04 0.03 - 0.05
20–39	286	90.21	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.02
40–59	315	43.81	—	—	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.02 - 0.02	0.03 0.02 - 0.04	0.04 0.03 - 0.05
60–79	266	11.28	0.02 0.02 - 0.03	0.02 0.02 - 0.02	<LOD	0.01 <LOD - 0.01	0.02 0.02 - 0.02	0.03 0.03 - 0.03	0.04 0.03 - 0.05	0.06 0.05 - 0.06

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.19b

2,2',3,4,4',5',6-Heptachlorobiphenyl (PCB 183) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	48.98	—	—	<LOD	<LOD	<LOD	2.69 2.30 - 3.07	4.64 3.77 - 5.51	6.57 5.39 - 7.74
20–39	525	91.24	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	2.18 <LOD - 3.56
40–59	596	46.31	—	—	<LOD	<LOD	1.61 <LOD - 1.96	2.77 2.28 - 3.25	4.45 2.92 - 5.97	6.46 4.98 - 7.94
60–79	545	11.19	4.11 3.60 - 4.62	3.10 2.70 - 3.57	<LOD	2.09 1.71 - 2.48	3.20 2.62 - 3.78	4.83 4.06 - 5.59	7.76 5.94 - 9.58	11.18 8.62 - 13.75
Males										
Total, age 20–79	801	48.69	—	—	<LOD	<LOD	<LOD	2.53 2.09 - 2.98	4.46 3.00 - 5.92	7.28 5.27 - 9.30
20–39	240	92.08	—	—	<LOD	<LOD	<LOD	<LOD	<LOD <LOD - 2.03	2.79 <LOD - 4.61
40–59	281	49.11	—	—	<LOD	<LOD	<LOD <LOD - 2.03	2.43 2.02 - 2.84	4.05 1.92 - 6.19	6.29 4.06 - 8.51
60–79	280	11.07	4.57 3.93 - 5.21	3.38 2.95 - 3.87	<LOD <LOD - 1.82	2.19 1.85 - 2.52	3.37 2.74 - 4.01	5.32 4.04 - 6.60	9.62 6.91 - 12.33	13.67 10.02 - 17.32
Females										
Total, age 20–79	865	49.25	—	—	<LOD	<LOD	<LOD	2.82 2.37 - 3.27	4.68 3.84 - 5.53	6.46 5.30 - 7.62
20–39	285	90.53	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	2.10 <LOD - 3.29
40–59	315	43.81	—	—	<LOD	<LOD	1.72 <LOD - 2.09	2.98 2.38 - 3.58	4.77 3.09 - 6.45	6.39 4.90 - 7.87
60–79	265	11.32	3.68 3.13 - 4.22	2.87 2.42 - 3.40	<LOD	1.91 <LOD - 2.45	2.96 2.34 - 3.58	4.57 4.03 - 5.12	6.52 5.56 - 7.49	8.44 6.90 - 9.99

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.20 2,2',3,4',5,5',6-Heptachlorobiphenyl (PCB 187)

Table 8.3.20a

2,2',3,4',5,5',6-Heptachlorobiphenyl (PCB 187) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	19.60	0.04 0.03 - 0.05	0.02 0.02 - 0.03	<LOD	0.01 <LOD - 0.01	0.02 0.02 - 0.03	0.04 0.04 - 0.05	0.09 0.07 - 0.11	0.13 0.10 - 0.16
20–39	526	56.08	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.03 0.02 - 0.04	0.04 0.03 - 0.05
40–59	596	5.20	0.04 0.03 - 0.05	0.03 0.03 - 0.04	0.01 0.01 - 0.01	0.02 0.02 - 0.02	0.03 0.03 - 0.03	0.04 0.04 - 0.05	0.07 0.04 - 0.10	0.12 0.07 - 0.16
60–79	546	0.18	0.08 0.07 - 0.10	0.06 0.05 - 0.07	0.03 0.02 - 0.03	0.04 0.03 - 0.04	0.06 0.05 - 0.07	0.10 0.08 - 0.12	0.16 0.12 - 0.19	0.23 0.18 - 0.28
Males										
Total, age 20–79	801	16.73	0.04 0.03 - 0.05	0.02 0.02 - 0.03	<LOD	0.01 <LOD - 0.01	0.02 0.02 - 0.03	0.04 0.04 - 0.05	0.09 0.06 - 0.13	0.14 0.10 - 0.19
20–39	240	52.92	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.02	0.03 0.02 - 0.04	0.03 0.02 - 0.05
40–59	281	2.49	0.04 0.03 - 0.05	0.03 0.03 - 0.04	0.01 <LOD - 0.02	0.02 0.02 - 0.02	0.03 0.03 - 0.04	0.04 0.04 - 0.05	0.08 0.03 - 0.12	0.12 0.06 - 0.17
60–79	280	0.00	0.09 0.08 - 0.11	0.07 0.06 - 0.08	0.03 0.03 - 0.04	0.04 0.03 - 0.05	0.07 0.05 - 0.08	0.11 0.08 - 0.13	0.19 0.12 - 0.26	0.25 0.19 - 0.31
Females										
Total, age 20–79	867	22.26	0.04 0.03 - 0.04	0.02 0.02 - 0.03	<LOD	0.01 <LOD - 0.01	0.02 0.02 - 0.03	0.05 0.04 - 0.05	0.08 0.06 - 0.10	0.12 0.09 - 0.15
20–39	286	58.74	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.02 0.01 - 0.03	0.04 0.02 - 0.05
40–59	315	7.62	0.04 0.03 - 0.05	0.03 0.03 - 0.03	0.01 <LOD - 0.02	0.02 0.02 - 0.02	0.03 0.03 - 0.04	0.05 0.03 - 0.06	0.07 0.04 - 0.10	0.11 0.07 - 0.16
60–79	266	0.38	0.07 0.06 - 0.09	0.06 0.05 - 0.07	0.02 0.01 - 0.03	0.04 0.03 - 0.05	0.05 0.05 - 0.06	0.09 0.07 - 0.10	0.13 0.10 - 0.16	0.18 0.12 - 0.23

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.20b

2,2',3,4',5,5',6-Heptachlorobiphenyl (PCB 187) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	19.63	6.35 5.28 - 7.42	3.72 3.21 - 4.31	<LOD	1.79 <LOD - 2.41	3.95 3.38 - 4.51	7.26 6.03 - 8.49	13.33 9.84 - 16.81	19.87 13.23 - 26.51
20–39	525	56.19	—	—	<LOD	<LOD	<LOD	2.59 1.73 - 3.45	4.82 3.35 - 6.28	6.19 3.33 - 9.06
40–59	596	5.20	6.70 5.25 - 8.14	4.93 4.20 - 5.78	2.16 1.88 - 2.44	3.26 2.88 - 3.64	4.69 4.07 - 5.32	7.08 5.52 - 8.65	13.00 8.72 - 17.29	18.07 8.05 - 28.09
60–79	545	0.18	12.93 10.93 - 14.94	9.57 8.18 - 11.21	4.18 3.38 - 4.98	6.13 5.22 - 7.04	9.14 7.33 - 10.95	14.41 10.79 - 18.03	25.10 17.79 - 32.42	34.98 28.47 - 41.50
Males										
Total, age 20–79	801	16.73	6.66 5.42 - 7.89	3.78 3.22 - 4.44	<LOD	1.89 <LOD - 2.49	4.00 3.49 - 4.52	7.37 5.84 - 8.89	14.11 8.81 - 19.40	23.45 14.08 - 32.81
20–39	240	52.92	—	—	<LOD	<LOD	<LOD	2.53 <LOD - 3.82	4.71 3.40 - 6.02	5.48 0.22 - 10.73
40–59	281	2.49	6.81 5.02 - 8.59	5.00 4.14 - 6.04	2.06 <LOD - 2.49	3.24 2.64 - 3.84	4.63 3.93 - 5.33	6.76 5.14 - 8.38	12.97 4.65 - 21.30	20.95 7.89 - 34.00
60–79	280	0.00	14.75 12.38 - 17.12	11.01 9.41 - 12.89	4.75 3.88 - 5.61	6.54 5.13 - 7.94	10.28 7.97 - 12.59	17.08 12.61 - 21.55	29.98 22.96 - 37.01	41.96 28.89 - 55.03
Females										
Total, age 20–79	865	22.31	6.04 5.01 - 7.08	3.66 3.16 - 4.25	<LOD	1.56 <LOD - 2.28	3.93 3.15 - 4.70	7.25 5.94 - 8.55	12.97 9.76 - 16.18	18.03 14.10 - 21.96
20–39	285	58.95	—	—	<LOD	<LOD	<LOD	2.62 1.79 - 3.45	5.02 2.54 - 7.49	6.49 3.95 - 9.04
40–59	315	7.62	6.59 5.19 - 7.98	4.86 4.19 - 5.63	2.17 <LOD - 2.58	3.26 2.94 - 3.59	4.78 4.08 - 5.48	7.26 5.09 - 9.42	13.02 8.56 - 17.48	17.17 10.53 - 23.80
60–79	265	0.38	11.25 9.05 - 13.45	8.41 6.94 - 10.19	3.70 2.65 - 4.74	5.46 4.38 - 6.53	8.25 6.45 - 10.05	12.88 9.54 - 16.22	19.14 14.74 - 23.53	26.88 18.53 - 35.22

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.21 2,2',3,3',4,4',5,5'-Octachlorobiphenyl (PCB 194)

Table 8.3.21a

2,2',3,3',4,4',5,5'-Octachlorobiphenyl (PCB 194) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	29.50	0.03 0.03 - 0.04	0.02 0.02 - 0.02	<LOD	<LOD	0.02 0.02 - 0.02	0.04 0.03 - 0.05	0.07 0.06 - 0.08	0.10 0.08 - 0.13
20–39	526	80.80	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.02	0.02 <LOD - 0.03
40–59	596	10.40	0.03 0.03 - 0.04	0.02 0.02 - 0.03	0.01 <LOD - 0.01	0.02 0.01 - 0.02	0.02 0.02 - 0.03	0.04 0.03 - 0.04	0.06 0.04 - 0.08	0.09 0.04 - 0.13
60–79	546	0.92	0.07 0.06 - 0.08	0.05 0.05 - 0.06	0.02 0.02 - 0.03	0.04 0.03 - 0.04	0.06 0.05 - 0.06	0.08 0.07 - 0.09	0.13 0.10 - 0.16	0.19 0.12 - 0.27
Males										
Total, age 20–79	801	24.72	0.03 0.03 - 0.04	0.02 0.02 - 0.02	<LOD	<LOD	0.02 0.02 - 0.02	0.04 0.04 - 0.05	0.08 0.06 - 0.10	0.12 0.07 - 0.18
20–39	240	74.17	—	—	<LOD	<LOD	<LOD	<LOD	0.02 <LOD - 0.02	0.02 0.01 - 0.03
40–59	281	6.76	0.04 0.02 - 0.05	0.03 0.02 - 0.03	0.01 <LOD - 0.02	0.02 0.01 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.05	0.06 0.03 - 0.10	0.09 0.02 - 0.15
60–79	280	0.36	0.08 0.06 - 0.10	0.06 0.06 - 0.07	0.03 0.02 - 0.03	0.04 0.03 - 0.05	0.06 0.06 - 0.06	0.10 0.07 - 0.12	0.16 0.11 - 0.20	0.21 0.12 - 0.29
Females										
Total, age 20–79	867	33.91	0.03 0.02 - 0.03	0.02 0.02 - 0.02	<LOD	<LOD	0.02 0.02 - 0.02	0.04 0.03 - 0.04	0.06 0.06 - 0.07	0.09 0.06 - 0.11
20–39	286	86.36	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.02	0.03 <LOD - 0.06
40–59	315	13.65	0.03 0.02 - 0.04	0.02 0.02 - 0.03	0.01 <LOD - 0.01	0.01 0.01 - 0.02	0.02 0.02 - 0.03	0.03 0.03 - 0.04	0.05 0.04 - 0.06	0.07 0.03 - 0.11
60–79	266	1.50	0.06 0.05 - 0.07	0.05 0.04 - 0.05	0.02 0.02 - 0.03	0.03 0.03 - 0.04	0.05 0.04 - 0.05	0.07 0.06 - 0.08	0.11 0.08 - 0.14	0.14 0.09 - 0.19

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.21b

2,2',3,3',4,4',5,5'-Octachlorobiphenyl (PCB 194) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	29.53	5.25 4.20 - 6.30	2.91 2.59 - 3.29	<LOD	<LOD	3.03 2.63 - 3.44	6.20 5.13 - 7.27	11.64 9.80 - 13.48	16.15 11.84 - 20.47
20–39	525	80.95	—	—	<LOD	<LOD	<LOD	<LOD	2.41 <LOD - 3.41	3.41 <LOD - 6.02
40–59	596	10.40	5.54 4.16 - 6.91	3.93 3.34 - 4.62	1.59 <LOD - 2.28	2.55 2.06 - 3.04	3.90 3.34 - 4.46	5.95 4.83 - 7.07	10.56 7.33 - 13.79	14.64 6.30 - 22.99
60–79	545	0.92	11.33 8.97 - 13.68	8.48 7.60 - 9.46	3.81 3.19 - 4.42	5.41 4.73 - 6.10	8.54 7.44 - 9.63	12.61 10.77 - 14.44	19.36 12.37 - 26.36	31.22 12.85 - 49.59
Males										
Total, age 20–79	801	24.72	5.77 4.46 - 7.08	3.06 2.66 - 3.52	<LOD	<LOD	3.12 2.69 - 3.55	6.72 5.28 - 8.17	12.75 9.95 - 15.54	19.38 7.78 - 30.98
20–39	240	74.17	—	—	<LOD	<LOD	<LOD	<LOD	2.76 <LOD - 3.81	3.39 2.62 - 4.17
40–59	281	6.76	6.14 4.06 - 8.21	4.24 3.42 - 5.24	1.75 <LOD - 2.68	2.72 2.12 - 3.31	4.10 3.46 - 4.74	6.44 4.60 - 8.28	11.77 5.62 - 17.92	18.15 4.79 - 31.50
60–79	280	0.36	13.29 9.71 - 16.86	10.16 8.50 - 12.15	4.44 3.30 - 5.58	6.52 5.30 - 7.74	10.32 9.05 - 11.60	14.27 11.35 - 17.18	27.91 17.60 - 38.22	31.90 7.49 - 56.31
Females										
Total, age 20–79	865	33.99	4.73 3.87 - 5.60	2.78 2.48 - 3.11	<LOD	<LOD	2.93 2.39 - 3.46	5.90 4.99 - 6.81	10.67 8.71 - 12.63	13.49 10.67 - 16.31
20–39	285	86.67	—	—	<LOD	<LOD	<LOD	<LOD	1.91 <LOD - 4.17	5.69 <LOD - 11.56
40–59	315	13.65	4.94 3.84 - 6.04	3.65 3.16 - 4.21	1.51 <LOD - 2.12	2.30 1.97 - 2.62	3.66 3.10 - 4.22	5.58 4.57 - 6.60	8.63 6.01 - 11.24	12.33 8.23 - 16.42
60–79	265	1.51	9.51 8.00 - 11.02	7.17 6.39 - 8.04	3.41 2.50 - 4.32	5.08 4.48 - 5.68	7.37 6.43 - 8.30	10.77 9.74 - 11.79	14.35 11.42 - 17.29	19.59 13.53 - 25.66

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.22 2,2',3,3',4,5',6,6'-Octachlorobiphenyl (PCB 201)

Table 8.3.22a

2,2',3,3',4,5',6,6'-Octachlorobiphenyl (PCB 201) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	30.88	0.03 0.02 - 0.03	0.02 0.01 - 0.02	<LOD	<LOD	0.02 0.01 - 0.02	0.03 0.03 - 0.04	0.06 0.05 - 0.07	0.09 0.06 - 0.11
20–39	526	82.32	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.02	0.02 0.01 - 0.02
40–59	596	13.26	0.03 0.02 - 0.03	0.02 0.02 - 0.02	<LOD	0.01 0.01 - 0.01	0.02 0.02 - 0.02	0.03 0.03 - 0.04	0.05 0.03 - 0.07	0.08 0.04 - 0.11
60–79	546	0.55	0.06 0.05 - 0.07	0.05 0.04 - 0.05	0.02 0.02 - 0.02	0.03 0.03 - 0.03	0.04 0.04 - 0.05	0.07 0.06 - 0.08	0.11 0.07 - 0.14	0.19 0.13 - 0.24
Males										
Total, age 20–79	801	25.97	0.03 0.02 - 0.03	0.02 0.01 - 0.02	<LOD	<LOD	0.02 0.01 - 0.02	0.03 0.02 - 0.04	0.06 0.05 - 0.08	0.10 0.08 - 0.13
20–39	240	75.83	—	—	<LOD	<LOD	<LOD	<LOD <LOD - 0.01	0.01 0.01 - 0.02	0.02 0.01 - 0.02
40–59	281	9.25	0.03 0.02 - 0.03	0.02 0.02 - 0.03	<LOD <LOD - 0.01	0.01 0.01 - 0.01	0.02 0.02 - 0.02	0.03 0.02 - 0.04	0.05 0.03 - 0.08	0.08 0.03 - 0.13
60–79	280	0.00	0.07 0.06 - 0.08	0.05 0.05 - 0.06	0.02 0.02 - 0.03	0.03 0.02 - 0.04	0.05 0.04 - 0.06	0.08 0.06 - 0.10	0.15 0.09 - 0.20	0.21 0.17 - 0.25
Females										
Total, age 20–79	867	35.41	0.03 0.02 - 0.03	0.01 0.01 - 0.02	<LOD	<LOD	0.02 0.01 - 0.02	0.03 0.03 - 0.04	0.05 0.04 - 0.06	0.08 0.06 - 0.10
20–39	286	87.76	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.02	0.02 <LOD - 0.04
40–59	315	16.83	0.03 0.02 - 0.03	0.02 0.02 - 0.02	<LOD	0.01 0.01 - 0.01	0.02 0.02 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.05	0.07 0.04 - 0.10
60–79	266	1.13	0.05 0.04 - 0.06	0.04 0.04 - 0.05	0.02 0.01 - 0.02	0.03 0.02 - 0.03	0.04 0.04 - 0.04	0.06 0.05 - 0.07	0.09 0.06 - 0.11	0.13 0.08 - 0.18

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.22b

2,2',3,3',4,5',6,6'-Octachlorobiphenyl (PCB 201) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	30.91	4.45 3.68 - 5.23	2.60 2.33 - 2.89	<LOD	<LOD	2.50 2.18 - 2.82	5.10 4.25 - 5.96	9.34 7.77 - 10.90	14.30 9.95 - 18.64
20–39	525	82.48	—	—	<LOD	<LOD	<LOD	<LOD	2.32 <LOD - 2.84	3.24 1.78 - 4.71
40–59	596	13.26	4.47 3.52 - 5.41	3.28 2.83 - 3.80	<LOD	2.08 1.85 - 2.31	3.15 2.71 - 3.60	4.90 4.04 - 5.75	8.81 6.33 - 11.29	12.55 6.22 - 18.88
60–79	545	0.55	9.87 7.96 - 11.78	7.27 6.47 - 8.18	3.32 2.87 - 3.77	4.58 3.73 - 5.44	7.19 6.22 - 8.16	10.08 8.14 - 12.03	17.07 13.38 - 20.76	27.71 11.48 - 43.94
Males										
Total, age 20–79	801	25.97	4.78 3.91 - 5.65	2.69 2.38 - 3.05	<LOD	<LOD	2.43 2.13 - 2.74	5.16 3.60 - 6.72	10.33 6.92 - 13.73	17.30 12.76 - 21.85
20–39	240	75.83	—	—	<LOD	<LOD	<LOD	<LOD <LOD - 2.00	2.37 2.00 - 2.74	2.93 1.80 - 4.07
40–59	281	9.25	4.69 3.52 - 5.87	3.42 2.84 - 4.13	<LOD <LOD - 1.93	2.09 1.79 - 2.39	3.18 2.68 - 3.69	4.90 3.17 - 6.63	9.43 4.55 - 14.31	13.69 5.50 - 21.88
60–79	280	0.00	11.52 8.80 - 14.23	8.65 7.27 - 10.28	3.59 2.59 - 4.59	5.55 4.26 - 6.84	8.15 7.10 - 9.20	13.04 9.14 - 16.93	21.38 14.27 - 28.48	30.51 15.01 - 46.02
Females										
Total, age 20–79	865	35.49	4.13 3.38 - 4.88	2.50 2.25 - 2.79	<LOD	<LOD	2.58 2.10 - 3.06	5.09 4.32 - 5.87	8.51 7.40 - 9.63	11.32 8.81 - 13.83
20–39	285	88.07	—	—	<LOD	<LOD	<LOD	<LOD	1.95 <LOD - 3.38	4.69 <LOD - 9.16
40–59	315	16.83	4.24 3.25 - 5.22	3.14 2.76 - 3.58	<LOD	2.01 1.72 - 2.29	3.13 2.64 - 3.62	4.79 3.91 - 5.68	7.31 4.91 - 9.72	10.24 6.70 - 13.77
60–79	265	1.13	8.35 6.78 - 9.92	6.19 5.40 - 7.10	3.11 2.31 - 3.90	4.21 3.49 - 4.92	6.34 5.38 - 7.30	8.97 7.89 - 10.05	13.15 10.21 - 16.09	17.60 11.19 - 24.00

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.23 2,2',3,4,4',5,5',6-Octachlorobiphenyl (PCB 203)

Table 8.3.23a

2,2',3,4,4',5,5',6-Octachlorobiphenyl (PCB 203) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	35.61	0.02 0.02 - 0.03	0.01 0.01 - 0.01	<LOD	<LOD	0.01 0.01 - 0.01	0.03 0.02 - 0.03	0.05 0.04 - 0.06	0.07 0.05 - 0.09
20–39	526	89.73	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.01 <LOD - 0.02
40–59	596	19.30	0.02 0.02 - 0.03	0.02 0.01 - 0.02	<LOD	0.01 0.01 - 0.01	0.02 0.01 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.05	0.06 0.04 - 0.08
60–79	546	1.28	0.05 0.04 - 0.06	0.04 0.04 - 0.04	0.02 0.01 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.04	0.06 0.05 - 0.07	0.09 0.08 - 0.10	0.13 0.10 - 0.16
Males										
Total, age 20–79	801	31.84	0.02 0.02 - 0.03	0.01 0.01 - 0.02	<LOD	<LOD	0.01 0.01 - 0.01	0.03 0.02 - 0.03	0.05 0.04 - 0.07	0.08 0.06 - 0.11
20–39	240	87.08	—	—	<LOD	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.01 0.01 - 0.01
40–59	281	15.30	0.02 0.02 - 0.03	0.02 0.01 - 0.02	<LOD	0.01 0.01 - 0.01	0.02 0.01 - 0.02	0.03 0.02 - 0.04	0.04 0.02 - 0.06	0.06 0.01 - 0.10
60–79	280	1.07	0.06 0.05 - 0.06	0.04 0.04 - 0.05	0.02 0.02 - 0.02	0.03 0.02 - 0.03	0.04 0.04 - 0.05	0.07 0.06 - 0.08	0.10 0.08 - 0.12	0.14 0.11 - 0.16
Females										
Total, age 20–79	867	39.10	0.02 0.02 - 0.02	0.01 0.01 - 0.01	<LOD	<LOD	0.01 0.01 - 0.02	0.03 0.02 - 0.03	0.05 0.04 - 0.05	0.06 0.05 - 0.07
20–39	286	91.96	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.02 <LOD - 0.04
40–59	315	22.86	0.02 0.02 - 0.03	0.02 0.01 - 0.02	<LOD	0.01 <LOD - 0.01	0.02 0.01 - 0.02	0.02 0.02 - 0.03	0.04 0.03 - 0.05	0.05 0.04 - 0.07
60–79	266	1.50	0.04 0.04 - 0.05	0.03 0.03 - 0.04	0.01 <LOD - 0.02	0.02 0.02 - 0.03	0.04 0.03 - 0.04	0.05 0.04 - 0.06	0.08 0.06 - 0.10	0.09 0.07 - 0.12

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.23b

2,2',3,4,4',5,5',6-Octachlorobiphenyl (PCB 203) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	35.65	3.62 3.10 - 4.14	2.25 2.04 - 2.47	<LOD	<LOD	2.17 1.89 - 2.45	4.47 3.81 - 5.13	8.00 6.78 - 9.21	10.96 8.42 - 13.50
20–39	525	89.90	—	—	<LOD	<LOD	<LOD	<LOD	1.64 <LOD - 2.20	2.88 <LOD - 4.54
40–59	596	19.30	3.70 3.02 - 4.38	2.76 2.40 - 3.17	<LOD	1.76 1.45 - 2.08	2.83 2.52 - 3.14	4.19 3.46 - 4.92	6.80 5.41 - 8.19	8.50 4.39 - 12.62
60–79	545	1.28	7.74 6.68 - 8.80	6.05 5.45 - 6.71	2.67 2.18 - 3.15	4.01 3.36 - 4.66	6.09 5.35 - 6.83	9.10 8.00 - 10.20	14.18 10.97 - 17.38	19.27 15.22 - 23.33
Males										
Total, age 20–79	801	31.84	3.84 3.22 - 4.46	2.28 2.04 - 2.56	<LOD	<LOD	2.14 1.73 - 2.56	4.55 3.55 - 5.54	8.52 6.47 - 10.56	13.30 8.97 - 17.63
20–39	240	87.08	—	—	<LOD	<LOD	<LOD	<LOD	1.64 <LOD - 2.14	2.23 1.27 - 3.20
40–59	281	15.30	3.96 2.93 - 4.98	2.86 2.36 - 3.48	<LOD	1.78 1.33 - 2.22	2.82 2.40 - 3.23	4.28 2.88 - 5.68	7.19 4.08 - 10.31	11.46 4.83 - 18.10
60–79	280	1.07	8.82 7.42 - 10.22	7.00 6.09 - 8.05	3.09 2.31 - 3.87	4.50 3.52 - 5.48	7.06 6.02 - 8.10	10.68 8.61 - 12.75	17.27 13.75 - 20.78	20.61 13.51 - 27.72
Females										
Total, age 20–79	865	39.19	3.39 2.89 - 3.89	2.21 2.01 - 2.43	<LOD	<LOD	2.20 1.84 - 2.57	4.43 3.76 - 5.10	7.41 6.11 - 8.71	9.40 8.12 - 10.67
20–39	285	92.28	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	3.80 <LOD - 7.61
40–59	315	22.86	3.44 2.84 - 4.04	2.66 2.37 - 2.99	<LOD	1.75 <LOD - 2.08	2.86 2.50 - 3.22	4.14 3.51 - 4.78	6.01 5.01 - 7.01	7.67 5.32 - 10.03
60–79	265	1.51	6.74 5.76 - 7.71	5.28 4.65 - 5.99	2.53 <LOD - 3.15	3.59 2.78 - 4.40	5.57 4.71 - 6.42	7.94 6.80 - 9.07	10.78 8.99 - 12.58	14.21 10.00 - 18.42

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.24 2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (PCB 206)

Table 8.3.24a

2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (PCB 206) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	56.89	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.02 0.02 - 0.03	0.03 0.03 - 0.04
20–39	526	97.91	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	596	62.75	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.02 0.01 - 0.03	0.03 0.02 - 0.04
60–79	546	10.99	0.02 0.02 - 0.03	0.02 0.02 - 0.02	<LOD	0.01 0.01 - 0.01	0.02 0.02 - 0.02	0.03 0.03 - 0.03	0.04 0.03 - 0.05	0.06 0.04 - 0.07
Males										
Total, age 20–79	801	53.93	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.05
20–39	240	98.75	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	61.21	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.02 0.01 - 0.03	0.03 0.02 - 0.04
60–79	280	8.21	0.03 0.02 - 0.03	0.02 0.02 - 0.02	0.01 <LOD - 0.01	0.01 0.01 - 0.02	0.02 0.02 - 0.02	0.03 0.03 - 0.04	0.05 0.03 - 0.06	0.07 0.05 - 0.08
Females										
Total, age 20–79	867	59.63	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.02 0.02 - 0.03	0.03 0.03 - 0.04
20–39	286	97.20	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD <LOD - 0.02
40–59	315	64.13	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.02 0.01 - 0.02	0.02 0.01 - 0.03
60–79	266	13.91	0.02 0.02 - 0.03	0.02 0.01 - 0.02	<LOD	0.01 0.01 - 0.01	0.02 0.02 - 0.02	0.03 0.02 - 0.03	0.04 0.03 - 0.05	0.05 0.04 - 0.06

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.24b

2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (PCB 206) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (μg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	56.96	—	—	<LOD	<LOD	<LOD	2.19 1.85 - 2.54	3.85 3.00 - 4.70	5.46 4.37 - 6.54
20–39	525	98.10	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	596	62.75	—	—	<LOD	<LOD	<LOD	2.12 1.71 - 2.52	3.20 2.09 - 4.30	5.07 2.87 - 7.26
60–79	545	11.01	3.75 3.21 - 4.29	2.90 2.52 - 3.33	<LOD	1.96 1.61 - 2.32	3.01 2.62 - 3.40	4.62 3.94 - 5.31	6.40 4.85 - 7.96	9.23 6.30 - 12.16
Males										
Total, age 20–79	801	53.93	—	—	<LOD	<LOD	<LOD	2.22 1.77 - 2.67	4.46 3.34 - 5.57	6.10 4.12 - 8.07
20–39	240	98.75	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	281	61.21	—	—	<LOD	<LOD	<LOD	2.16 1.60 - 2.73	3.85 1.59 - 6.11	5.44 3.08 - 7.81
60–79	280	8.21	4.25 3.62 - 4.88	3.31 2.80 - 3.91	1.31 <LOD - 1.93	2.26 1.80 - 2.72	3.27 2.78 - 3.77	4.92 4.10 - 5.73	8.04 5.57 - 10.50	11.52 8.20 - 14.84
Females										
Total, age 20–79	865	59.77	—	—	<LOD	<LOD	<LOD	2.17 1.81 - 2.52	3.60 3.12 - 4.07	4.95 3.92 - 5.98
20–39	285	97.54	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD <LOD - 3.50
40–59	315	64.13	—	—	<LOD	<LOD	<LOD	1.96 1.62 - 2.29	2.96 2.29 - 3.63	3.61 2.63 - 4.58
60–79	265	13.96	3.29 2.73 - 3.84	2.56 2.22 - 2.96	<LOD	1.74 1.32 - 2.16	2.73 2.40 - 3.07	4.20 3.44 - 4.95	5.72 4.91 - 6.54	6.79 5.05 - 8.52

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.3.25 Total PCBs (Measured as Aroclor 1260)

■ Table 8.3.25a

Aroclor 1260 – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	0.42	1.40 1.22 - 1.59	0.90 0.79 - 1.03	0.26 0.20 - 0.31	0.47 0.40 - 0.54	0.93 0.84 - 1.03	1.75 1.51 - 1.98	3.10 2.56 - 3.65	4.17 3.32 - 5.02
20–39	526	0.95	0.54 0.43 - 0.66	0.41 0.34 - 0.50	0.19 0.14 - 0.24	0.25 0.20 - 0.30	0.40 0.31 - 0.49	0.64 0.48 - 0.80	0.99 0.64 - 1.35	1.41 1.06 - 1.75
40–59	596	0.34	1.51 1.28 - 1.74	1.17 1.03 - 1.32	0.52 0.46 - 0.58	0.81 0.73 - 0.90	1.15 1.01 - 1.28	1.80 1.51 - 2.08	2.76 2.22 - 3.30	3.88 2.54 - 5.22
60–79	546	0.00	2.73 2.35 - 3.12	2.21 1.92 - 2.55	0.98 0.83 - 1.13	1.42 1.21 - 1.63	2.19 1.86 - 2.52	3.52 2.97 - 4.07	4.91 3.91 - 5.92	6.33 4.99 - 7.67
Males										
Total, age 20–79	801	0.25	1.38 1.16 - 1.61	0.89 0.78 - 1.01	0.26 0.21 - 0.32	0.45 0.39 - 0.51	0.91 0.81 - 1.01	1.61 1.41 - 1.81	3.08 2.20 - 3.96	4.18 2.85 - 5.50
20–39	240	0.83	0.54 0.41 - 0.67	0.42 0.34 - 0.51	0.20 0.16 - 0.25	0.26 0.21 - 0.31	0.39 0.29 - 0.49	0.59 0.38 - 0.80	1.15 0.75 - 1.56	1.38 1.01 - 1.74
40–59	281	0.00	1.44 1.16 - 1.72	1.13 0.99 - 1.30	0.50 0.40 - 0.61	0.79 0.62 - 0.95	1.05 0.91 - 1.18	1.63 1.31 - 1.96	2.63 1.51 - 3.75	3.91 2.25 - 5.57
60–79	280	0.00	2.89 2.37 - 3.40	2.31 1.98 - 2.68	1.01 0.84 - 1.17	1.43 1.26 - 1.60	2.19 1.69 - 2.70	3.66 2.99 - 4.32	5.41 3.98 - 6.84	6.88 4.69 - 9.06
Females										
Total, age 20–79	867	0.58	1.42 1.24 - 1.60	0.91 0.78 - 1.06	0.23 0.16 - 0.30	0.49 0.38 - 0.59	0.97 0.83 - 1.11	1.88 1.62 - 2.14	3.15 2.67 - 3.64	4.16 3.44 - 4.87
20–39	286	1.05	0.55 0.42 - 0.68	0.40 0.32 - 0.52	0.16 0.11 - 0.21	0.24 0.17 - 0.31	0.40 0.30 - 0.50	0.68 0.51 - 0.86	0.91 0.52 - 1.30	1.46 0.86 - 2.07
40–59	315	0.63	1.58 1.34 - 1.83	1.20 1.03 - 1.39	0.53 0.48 - 0.57	0.85 0.78 - 0.93	1.21 1.01 - 1.41	1.95 1.62 - 2.27	2.77 2.17 - 3.37	3.75 2.58 - 4.91
60–79	266	0.00	2.59 2.24 - 2.94	2.13 1.82 - 2.49	0.91 0.67 - 1.16	1.41 1.03 - 1.78	2.18 1.84 - 2.52	3.30 2.88 - 3.71	4.54 3.97 - 5.10	5.54 4.45 - 6.64

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.25b

Aroclor 1260 (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	0.42	227.69 194.92 - 260.47	150.53 131.77 - 171.96	45.15 38.48 - 51.83	80.48 70.19 - 90.78	153.30 133.63 - 172.96	280.87 242.79 - 318.94	485.00 388.24 - 581.76	681.96 551.65 - 812.26
20–39	525	0.95	97.81 76.65 - 118.96	73.77 60.86 - 89.42	32.43 26.00 - 38.87	45.85 39.36 - 52.34	73.15 60.31 - 86.00	115.13 87.44 - 142.81	190.10 125.25 - 254.96	263.99 172.56 - 355.42
40–59	596	0.34	245.12 204.84 - 285.40	189.26 167.49 - 213.86	84.29 73.64 - 94.94	131.17 120.19 - 142.15	183.70 164.70 - 202.69	281.28 227.52 - 335.03	436.22 311.30 - 561.14	667.00 441.25 - 892.76
60–79	545	0.00	425.93 365.35 - 486.52	343.72 299.79 - 394.09	153.27 136.90 - 169.64	232.59 202.13 - 263.04	344.21 292.08 - 396.35	522.86 435.51 - 610.21	745.66 602.74 - 888.58	1057.11 772.69 - 1341.52
Males										
Total, age 20–79	801	0.25	226.69 187.93 - 265.44	148.43 129.50 - 170.13	48.96 40.71 - 57.21	73.94 60.40 - 87.48	146.06 123.08 - 169.04	268.05 219.49 - 316.61	477.89 343.95 - 611.83	725.12 508.46 - 941.79
20–39	240	0.83	94.69 70.71 - 118.67	73.01 58.96 - 90.41	33.33 23.45 - 43.22	46.41 38.46 - 54.37	68.56 54.32 - 82.80	108.62 77.92 - 139.31	189.80 123.01 - 256.58	232.89 113.52 - 352.27
40–59	281	0.00	236.41 185.60 - 287.22	185.18 160.34 - 213.88	83.77 70.27 - 97.27	121.85 108.36 - 135.34	177.75 151.98 - 203.53	258.24 201.21 - 315.27	425.73 210.99 - 640.47	718.57 320.74 - 1116.39
60–79	280	0.00	459.23 379.65 - 538.81	366.53 317.49 - 423.15	163.04 134.48 - 191.60	239.07 215.45 - 262.69	344.36 287.42 - 401.30	538.25 385.85 - 690.65	823.04 552.02 - 1094.06	1170.19 835.14 - 1505.25
Females										
Total, age 20–79	865	0.58	228.70 196.43 - 260.98	152.67 131.51 - 177.22	44.66 33.96 - 55.36	84.26 73.49 - 95.04	160.80 138.14 - 183.47	286.24 237.95 - 334.53	500.73 395.54 - 605.92	631.36 517.72 - 745.01
20–39	285	1.05	101.11 74.90 - 127.32	74.57 58.52 - 95.03	29.76 21.85 - 37.67	44.79 34.18 - 55.40	80.53 65.45 - 95.61	123.97 88.61 - 159.34	191.99 102.74 - 281.24	270.00 148.99 - 391.01
40–59	315	0.63	253.81 211.66 - 295.96	193.42 166.67 - 224.46	84.57 72.35 - 96.78	140.23 129.84 - 150.63	192.50 159.86 - 225.14	304.13 227.03 - 381.23	476.27 317.70 - 634.84	624.87 456.17 - 793.57
60–79	265	0.00	395.06 338.68 - 451.44	323.84 277.40 - 378.06	152.95 127.67 - 178.22	221.36 175.41 - 267.30	335.76 266.11 - 405.41	503.17 412.49 - 593.85	670.77 568.21 - 773.34	832.96 607.56 - 1058.37

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

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8.4 POLYBROMINATED FLAME RETARDANTS

Polybrominated diphenyl ethers (PBDEs) (also called polybrominated diphenyl oxides) and polybrominated biphenyls (PBBs) are two structurally related classes of persistent organic compounds, which are used as fire retardants. There are 209 possible congeners in each chemical class, varying in the number of bromine atoms and their locations on the two benzene rings.

This summary addresses PBDEs and PBBs in general, as well as the following specific congeners:

IUPAC No.	Compound Name	CASRN
PBB 153	2,2',4,4',5,5'-Hexabromobiphenyl	59080-40-9
PBDE 15	4,4'-Dibromodiphenyl ether	2050-47-7
PBDE 17	2,2',4-Tribromodiphenyl ether	147217-75-2
PBDE 25	2,3',4-Tribromodiphenyl ether	147217-77-4
PBDE 28	2,4,4'-Tribromodiphenyl ether	41318-75-6
PBDE 33	2',3,4-Tribromodiphenyl ether	147217-78-5
PBDE 47	2,2',4,4'-Tetrabromodiphenyl ether	5436-43-1
PBDE 99	2,2',4,4',5-Pentabromodiphenyl ether	60348-60-9
PBDE 100	2,2',4,4'6-Pentabromodiphenyl ether	189084-64-8
PBDE 153	2,2',4,4',5,5'-Hexabromodiphenyl ether	68631-49-2

PBDE 209 (2,2',3,3',4,4',5,5',6,6'-decabromodiphenyl ether) (CASRN 1163-19-5), the predominant congener in the DecaBDE commercial mixture, was not measured in the current cycle of the Canadian Health Measures Survey (CHMS). Because of the ubiquitous presence of decaBDE, there are problems with laboratory contamination with PBDE 209; in addition, the analytical method used for assessing PBDE 209 has not yet been optimized (Birnbaum & Cohen Hubal, 2006; INSPQ, 2005).

PBDEs and PBBs do not occur naturally in the environment; they are produced synthetically as mixtures for application as fire retardants (Health Canada, 2006). PBDEs are not manufactured in Canada, but are imported in the form of chemical formulations, such as resins, polymers, or substrates that contain PBDEs; and in semi-finished or finished articles (Environment Canada, 2006a). The Government of Canada (2008) has implemented regulations prohibiting the manufacture in Canada of all seven PBDEs assessed under the *Canadian Environmental Protection Act, 1999* (CEPA 1999) (Tetra-, Penta-, Hexa-, Hepta-, Octa-, Nona-, and DecaBDEs) (CEPA 1999). These regulations also prohibit the use, sale, and import of raw materials (commercial mixtures, resins, polymers) containing PBDEs that meet the criteria for virtual elimination (TetraBDE, PentaBDE, HexaBDE) under CEPA 1999. Additional actions planned include a proposed Performance Agreement with industry, which aims to manage and reduce releases of DecaBDE from its use in plastic and textile manufacturing facilities, development of a regulation to control PBDEs in domestic and imported manufactured products, and development of a management strategy for PBDE-containing products at end-of-life (Government of Canada, 2009).

Polybrominated biphenyls appear on Schedule 1 of CEPA 1999, and are regulated under the *Polybrominated Biphenyls Regulations, 1989* (Environment Canada, 2009).

The Organisation for Economic Co-operation and Development (OECD) (2004) classifies Penta-, Octa-, and DecaBDE as High Production Volume (HPV) chemicals. The USA produces DecaBDE (ATSDR, 2004) and it is listed as an HPV chemical by the United States Environmental Protection Agency (US EPA, 2008).

Three commercial PBDE products (PentaBDE, OctaBDE, and DecaBDE), which differ in their composition, use, manufactured volume, toxicology, and environmental distribution, have been produced. Of these three products, only DecaBDE remains in widespread commercial use (BSEF, 2008). Results of a survey conducted in Canada indicate that, similar to other countries, the primary uses of DecaBDE are as a flame retardant in the manufacture of thermoplastics and polymer resins with widespread application in a variety of consumer products (Government of Canada, 2001). PentaBDE and OctaBDE were voluntarily phased out in the United States in 2004 (Sjödin et al., 2008). Prior to 2004, PentaBDE was commonly used in residential applications as a flame retardant in polyurethane foam, which is used in furniture and in the foam padding under wall-to-wall carpets. OctaBDE was used in plastic housings, office equipment, and electrical and electronic products (Birnbaum & Cohen Hubal, 2006).

PBBs were also historically used in fire retardants; PBB 153 was the predominant congener in a fire retardant with the trade name FireMaster. PBBs have not been manufactured since the 1970s; however, due to their persistence, they are still present in many environmental media (ATSDR, 2004).

The public may be exposed to PBDEs and PBBs in food, drinking water, soil, and air. Food, including breast milk, represents the principal source of exposure to PBDEs for the majority of age groups; dust is the principal source of exposure for the 0- to 6-month-old, non-breast-fed age group (Health Canada, 2006). The age group with potentially the greatest exposure is 0- to 6-month-old breast-fed infants, with breast milk accounting for 92% of the exposure. Health Canada (2006) concluded that exposure to PBDEs used in consumer products, via inhalation, dermal contact with dust, or oral contact with household products treated with flame retardants, is negligible in comparison with intake from food. However, other studies have found house dust to be the major source of exposure to PBDEs in adults, accounting for up to 82% of overall estimated intakes (Wilford et al., 2005; Lorber, 2008).

PBDEs have been measured in a variety of foods consumed by humans, with the highest concentrations reported for freshwater fish (1461.9 parts per trillion [ppt]) and marine fish (1164.9 ppt); PBDEs were also found in dairy products (e.g., 264.5 ppt in butter) and meats (e.g., 248.4 ppt in canned luncheon meat) (Health Canada, 2002).

The lower-brominated PBDEs and PBB 153 are persistent and accumulate in human adipose tissue, serum, and breast milk, and measured concentrations in these media are used as indicators of exposure (ATSDR, 2004). Higher brominated congeners tend to have shorter half-lives than lower brominated congeners (ATSDR, 2004). The higher brominated PBDEs (e.g., hepta- to decaBDEs) undergo debromination to form lower brominated congeners (e.g., tetra- to heptaBDEs), which are associated with high levels of bioaccumulation (Environment Canada, 2006b). Thus, the presence of a lower brominated congener in the body may be reflective of environmental exposure either to that congener or to the higher brominated PBDEs that have then undergone debromination. The predominant congeners identified in breast milk and other human tissues are PBDE 47, 99, 100, and 153.

Health Canada (2006) published a State of the Science Report for seven PBDE congener groups (Tetra-, Penta-, Hexa-, Hepta-, Octa-, Nona-, and DecaPBDEs). Comparison of the critical effect level (i.e., the lowest concentration at which relevant health effects occur; 0.8 mg/kg-bw, neurobehavioural effects in mice) with the upper-bounding deterministic estimate of exposure (i.e., the metric of exposure in which confidence is greatest) for intake of total PBDEs by the potentially most highly exposed age group (2.6 µg/kg-bw per day in breast-fed infants) resulted in a fairly conservative margin of exposure of approximately 300. Although there is considerable uncertainty in the estimates, given the regulatory actions being taken on the PBDEs due to environmental concerns, it is anticipated exposures to the general population will be reduced.

The International Agency for Research on Cancer (IARC) has classified PBBs as a possible human carcinogen (Group 2B), based on inadequate data in humans and sufficient evidence of carcinogenicity in animal studies (IARC, 1987). Animal studies have also shown liver, kidney, thyroid, and immune system effects from long-term exposure to very high doses. People reported as having been exposed to PBBs after eating meat from contaminated animals in Michigan experienced symptoms such as nausea, abdominal pain, reduced appetite, joint pain, fatigue, weakness, and skin problems, but it was not clear whether these symptoms were a result of the PBBs (ATSDR, 2004).

In a study of 110 post-menopausal women from the Québec City area, geometric mean and maximum concentrations (respectively) of PBDE congeners measured in blood plasma were as follows: 8.1 μg/kg lipid and 1780 μg/kg lipid for PBDE 47, 1.4 μg/kg lipid and 716 μg/kg lipid for PBDE 99, 1.1 μg/kg lipid and 366 μg/kg lipid for PBDE 100, and 1.4 μg/kg lipid 198 μg/kg lipid for PBDE 153 (Sandanger et al., 2007).

PBB 153, PBDE 15, PBDE 17, PBDE 25, PBDE 28, PBDE 33, PBDE 47, PBDE 99, PBDE 100, and PBDE 153 were measured in blood plasma in a subset of the CHMS sample, aged 20–79 years, and are presented as μg/L plasma and μg/kg lipid (Tables 8.4.1a – 8.4.10b). Participants were selected within the specified age range to be a representative sample of the Canadian population. Finding a measurable amount of PBDEs or PBBs in plasma is an indicator of exposure to PBDE or PBB compounds and does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for plasma levels of PBDEs and PBBs in the Canadian population.

8.4.1 2,2',4,4',5,5'-Hexabromobiphenyl (PBB 153)

■ Table 8.4.1a

2,2',4,4',5,5'-Hexabromobiphenyl (PBB 153) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (μg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1657	96.56	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	525	99.05	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	591	96.95	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	541	93.72	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.02 <LOD - 0.03
Males										
Total, age 20–79	798	94.74	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	97.92	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	279	95.70	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	279	91.04	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	0.03 <LOD - 0.05
Females										
Total, age 20–79	859	98.25	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	285	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	312	98.08	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	262	96.56	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.4.1b

2,2',4,4',5,5'-Hexabromobiphenyl (PBB 153) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1655	96.68	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	524	99.24	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	591	96.95	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	540	93.89	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	3.44 <LOD - 5.21
Males										
Total, age 20–79	798	94.74	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	97.92	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	279	95.70	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	279	91.04	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	4.72 <LOD - 8.19
Females										
Total, age 20–79	857	98.48	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	284	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	312	98.08	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	261	96.93	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.4.2 4,4'-Dibromodiphenyl Ether (PBDE 15)

Table 8.4.2a

4,4'-Dibromodiphenyl ether (PBDE 15) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1663	99.82	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	526	99.62	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	594	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	543	99.82	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	800	99.88	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	99.58	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	863	99.77	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	286	99.65	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	314	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	263	99.62	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.4.2b

4,4'-Dibromodiphenyl ether (PBDE 15) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1661	99.94	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	525	99.81	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	594	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	542	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	800	99.88	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	99.58	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	861	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	285	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	314	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	262	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.4.3 2,2',4-Tribromodiphenyl Ether (PBDE 17)

Table 8.4.3a

2,2',4-Tribromodiphenyl ether (PBDE 17) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1663	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	526	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	594	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	543	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	800	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	863	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	286	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	314	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	263	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.4.3b

2,2',4-Tribromodiphenyl ether (PBDE 17) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1661	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	525	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	594	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	542	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	800	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	861	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	285	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	314	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	262	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.4.4 2,3',4-Tribromodiphenyl Ether (PBDE 25)

Table 8.4.4a

2,3',4-Tribromodiphenyl ether (PBDE 25) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1663	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	526	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	594	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	543	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	800	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	863	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	286	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	314	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	263	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.4.4b

2,3',4-Tribromodiphenyl ether (PBDE 25) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1661	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	525	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	594	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	542	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	800	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	861	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	285	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	314	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	262	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.4.5 2,4,4'-Tribromodiphenyl Ether (PBDE 28)

Table 8.4.5a

2,4,4'-Tribromodiphenyl ether (PBDE 28) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1663	96.75	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	526	98.48	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	594	97.14	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	543	94.66	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	800	96.88	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	97.50	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	280	97.50	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	95.71	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	863	96.64	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	286	99.30	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	314	96.82	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	263	93.54	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.4.5b

2,4,4'-Tribromodiphenyl ether (PBDE 28) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1661	96.87	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	525	98.67	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	594	97.14	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	542	94.83	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	800	96.88	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	97.50	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	280	97.50	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	95.71	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	861	96.86	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	285	99.65	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	314	96.82	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	262	93.89	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.4.6 2',3,4-Tribromodiphenyl Ether (PBDE 33)

Table 8.4.6a

2',3,4-Tribromodiphenyl ether (PBDE 33) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1663	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	526	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	594	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	543	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	800	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	863	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	286	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	314	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	263	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.4.6b

2',3,4-Tribromodiphenyl ether (PBDE 33) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1661	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	525	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	594	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	542	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 20–79	800	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	240	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	280	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 20–79	861	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	285	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	314	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	262	100.00	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.4.7 2,2',4,4'-Tetrabromodiphenyl Ether (PBDE 47)

Table 8.4.7a

2,2',4,4'-Tetrabromodiphenyl ether (PBDE 47) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1668	25.24	0.13 0.11 - 0.16	0.06 0.05 - 0.07	<LOD	<LOD	0.06 0.05 - 0.07	0.12 0.10 - 0.14	0.26 0.23 - 0.29	0.41 0.33 - 0.49
20–39	526	21.10	0.12 0.09 - 0.15	0.06 0.05 - 0.07	<LOD	<LOD	0.05 0.03 - 0.07	0.11 0.10 - 0.13	0.26 0.22 - 0.30	0.42 0.26 - 0.58
40–59	596	26.17	0.14 0.09 - 0.19	0.06 0.05 - 0.07	<LOD	<LOD	0.06 0.05 - 0.07	0.13 0.10 - 0.17	0.25 0.20 - 0.29	0.39 0.24 - 0.55
60–79	546	28.21	0.14 0.10 - 0.19	0.06 0.05 - 0.07	<LOD	<LOD	0.06 0.05 - 0.07	0.14 0.10 - 0.17	0.27 0.19 - 0.34	0.41 0.20 - 0.62
Males										
Total, age 20–79	801	26.59	0.14 0.11 - 0.17	0.06 0.05 - 0.07	<LOD	<LOD	0.06 0.05 - 0.06	0.12 0.10 - 0.15	0.26 0.22 - 0.30	0.44 0.31 - 0.56
20–39	240	20.00	0.12 0.09 - 0.16	0.06 0.04 - 0.07	<LOD	<LOD	0.05 0.03 - 0.07	0.10 0.06 - 0.15	0.24 0.14 - 0.33	0.51 0.20 - 0.81
40–59	281	27.40	0.15 0.07 - 0.22	0.06 0.05 - 0.07	<LOD	<LOD	0.06 0.05 - 0.07	0.12 0.09 - 0.15	0.25 0.17 - 0.34	0.36 0.20 - 0.52
60–79	280	31.43	0.15 0.08 - 0.22	0.06 0.05 - 0.07	<LOD	<LOD	0.06 0.04 - 0.07	0.14 0.08 - 0.21	0.26 0.20 - 0.32	0.49 0.06 - 0.93
Females										
Total, age 20–79	867	23.99	0.13 0.10 - 0.15	0.06 0.05 - 0.07	<LOD	<LOD	0.06 0.05 - 0.07	0.12 0.10 - 0.15	0.26 0.22 - 0.30	0.40 0.30 - 0.49
20–39	286	22.03	0.12 0.08 - 0.16	0.06 0.05 - 0.07	<LOD	0.03 <LOD - 0.04	0.06 0.04 - 0.07	0.11 0.09 - 0.14	0.27 0.20 - 0.35	0.35 0.22 - 0.48
40–59	315	25.08	0.13 0.09 - 0.17	0.06 0.05 - 0.08	<LOD	<LOD	0.06 0.04 - 0.09	0.14 0.09 - 0.20	0.24 0.18 - 0.31	0.40 0.15 - 0.64
60–79	266	24.81	0.14 0.10 - 0.18	0.06 0.05 - 0.08	<LOD	0.03 <LOD - 0.04	0.06 0.05 - 0.08	0.13 0.09 - 0.16	0.29 0.17 - 0.41	0.40 0.33 - 0.48

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.4.7b

2,2',4,4'-Tetrabromodiphenyl ether (PBDE 47) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1666	25.27	21.71 17.48 - 25.94	10.04 9.06 - 11.12	<LOD	<LOD	9.71 8.43 - 10.99	20.60 18.04 - 23.16	44.20 39.55 - 48.86	66.60 50.63 - 82.56
20–39	525	21.14	21.34 16.41 - 26.28	10.33 8.77 - 12.17	<LOD	<LOD	10.13 7.94 - 12.31	19.28 16.63 - 21.93	50.18 42.11 - 58.25	74.09 40.89 - 107.29
40–59	596	26.17	21.57 13.92 - 29.23	9.95 8.76 - 11.30	<LOD	<LOD	9.49 7.82 - 11.16	21.54 16.74 - 26.35	39.62 30.99 - 48.26	62.94 44.93 - 80.96
60–79	545	28.26	22.65 15.92 - 29.38	9.70 8.41 - 11.19	<LOD	<LOD	9.29 7.47 - 11.11	21.32 16.94 - 25.70	44.39 31.69 - 57.09	69.81 42.32 - 97.31
Males										
Total, age 20–79	801	26.59	22.12 16.60 - 27.64	9.74 8.55 - 11.10	<LOD	<LOD	9.32 8.01 - 10.63	20.20 16.45 - 23.95	44.08 38.69 - 49.48	63.58 48.77 - 78.39
20–39	240	20.00	20.64 14.98 - 26.30	9.89 7.58 - 12.90	<LOD	<LOD	9.72 7.29 - 12.15	18.61 12.92 - 24.29	45.00 34.84 - 55.16	81.90 27.70 - 136.11
40–59	281	27.40	23.05 10.69 - 35.41	9.68 8.33 - 11.25	<LOD	<LOD	8.65 6.71 - 10.59	19.99 14.73 - 25.24	38.95 24.66 - 53.24	62.77 38.85 - 86.69
60–79	280	31.43	23.04 12.91 - 33.17	9.60 8.07 - 11.41	<LOD	<LOD	9.03 7.07 - 10.99	22.83 14.95 - 30.72	43.76 32.08 - 55.44	75.96 34.38 - 117.55
Females										
Total, age 20–79	865	24.05	21.30 17.12 - 25.49	10.34 8.95 - 11.94	<LOD	<LOD	10.07 7.93 - 12.20	20.92 17.39 - 24.46	44.76 35.73 - 53.79	70.85 48.05 - 93.65
20–39	285	22.11	22.08 14.51 - 29.65	10.83 9.06 - 12.94	<LOD	4.37 <LOD - 6.37	10.98 8.41 - 13.55	19.37 15.95 - 22.78	50.62 38.26 - 62.97	70.98 39.66 - 102.30
40–59	315	25.08	20.10 14.94 - 25.26	10.22 8.53 - 12.24	<LOD	<LOD	9.86 7.55 - 12.16	22.29 15.70 - 28.88	39.52 30.70 - 48.33	67.90 37.26 - 98.55
60–79	265	24.91	22.28 14.63 - 29.93	9.79 7.93 - 12.09	<LOD	3.61 <LOD - 5.25	9.64 7.12 - 12.15	19.88 14.30 - 25.45	45.40 26.65 - 64.15	67.45 43.11 - 91.79

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.4.8 2,2’,4,4’,5-Pentabromodiphenyl Ether (PBDE 99)

Table 8.4.8a

2,2’,4,4’,5-Pentabromodiphenyl ether (PBDE 99) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1665	73.21	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.04 0.04 - 0.05	0.08 0.07 - 0.09
20–39	526	72.62	—	—	<LOD	<LOD	<LOD	<LOD	0.04 0.03 - 0.05	0.08 0.05 - 0.10
40–59	594	75.93	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.05 0.04 - 0.06	0.07 0.04 - 0.10
60–79	545	70.83	—	—	<LOD	<LOD	<LOD	0.02 0.02 - 0.03	0.05 0.03 - 0.06	0.09 0.03 - 0.15
Males										
Total, age 20–79	800	72.75	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.05 0.04 - 0.06	0.08 0.05 - 0.11
20–39	240	70.42	—	—	<LOD	<LOD	<LOD	<LOD	0.04 0.02 - 0.07	0.10 0.04 - 0.16
40–59	280	76.07	—	—	<LOD	<LOD	<LOD	<LOD	0.04 0.03 - 0.06	0.06 0.04 - 0.08
60–79	280	71.43	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.06 0.03 - 0.08	0.12 0.02 - 0.23
Females										
Total, age 20–79	865	73.64	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.04 0.04 - 0.05	0.07 0.05 - 0.09
20–39	286	74.48	—	—	<LOD	<LOD	<LOD	<LOD	0.04 0.03 - 0.05	0.07 0.03 - 0.11
40–59	314	75.80	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.05 0.03 - 0.07	0.08 0.04 - 0.12
60–79	265	70.19	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.04 0.02 - 0.06	0.07 <LOD - 0.12

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.4.8b

2,2',4,4',5-Pentabromodiphenyl ether (PBDE 99) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1663	73.30	—	—	<LOD	<LOD	<LOD	3.22 <LOD - 4.22	7.53 6.76 - 8.30	12.63 11.48 - 13.79
20–39	525	72.76	—	—	<LOD	<LOD	<LOD	<LOD	7.49 5.84 - 9.14	13.78 10.63 - 16.94
40–59	594	75.93	—	—	<LOD	<LOD	<LOD	3.36 <LOD - 4.84	7.71 6.32 - 9.10	11.95 8.51 - 15.40
60–79	544	70.96	—	—	<LOD	<LOD	<LOD	3.78 2.96 - 4.60	7.58 4.91 - 10.25	13.61 5.32 - 21.90
Males										
Total, age 20–79	800	72.75	—	—	<LOD	<LOD	<LOD	2.96 <LOD - 3.94	7.74 6.60 - 8.88	12.62 9.77 - 15.48
20–39	240	70.42	—	—	<LOD	<LOD	<LOD	<LOD	7.82 3.43 - 12.20	15.12 9.41 - 20.83
40–59	280	76.07	—	—	<LOD	<LOD	<LOD	<LOD	7.22 4.83 - 9.61	9.98 6.12 - 13.84
60–79	280	71.43	—	—	<LOD	<LOD	<LOD	3.78 <LOD - 5.59	8.01 3.67 - 12.34	18.86 4.46 - 33.26
Females										
Total, age 20–79	863	73.81	—	—	<LOD	<LOD	<LOD	3.42 <LOD - 4.67	7.50 6.15 - 8.86	12.62 10.20 - 15.04
20–39	285	74.74	—	—	<LOD	<LOD	<LOD	<LOD	7.46 5.01 - 9.92	12.41 8.40 - 16.43
40–59	314	75.80	—	—	<LOD	<LOD	<LOD	4.00 <LOD - 6.18	8.05 5.21 - 10.89	12.45 8.17 - 16.73
60–79	264	70.45	—	—	<LOD	<LOD	<LOD	3.63 <LOD - 4.90	6.85 3.94 - 9.76	13.15 <LOD - 20.04

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.4.9 2,2',4,4',6-Pentabromodiphenyl Ether (PBDE 100)

Table 8.4.9a

2,2',4,4',6-Pentabromodiphenyl ether (PBDE 100) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1664	73.98	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.05 0.04 - 0.06	0.09 0.06 - 0.12
20–39	526	72.05	—	—	<LOD	<LOD	<LOD	<LOD	0.05 0.04 - 0.07	0.09 0.05 - 0.13
40–59	594	74.92	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.05 0.03 - 0.07	0.09 0.04 - 0.14
60–79	544	74.82	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.05 0.03 - 0.06	0.09 0.04 - 0.13
Males										
Total, age 20–79	800	73.75	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.05 0.04 - 0.06	0.09 0.06 - 0.12
20–39	240	68.33	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.05 0.03 - 0.07	0.10 <LOD - 0.19
40–59	280	76.43	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.02	0.04 0.03 - 0.06	0.08 0.03 - 0.12
60–79	280	75.71	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.05 0.03 - 0.06	0.09 <LOD - 0.19
Females										
Total, age 20–79	864	74.19	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.05 0.04 - 0.07	0.10 0.06 - 0.14
20–39	286	75.17	—	—	<LOD	<LOD	<LOD	<LOD	0.05 0.02 - 0.08	0.08 0.02 - 0.14
40–59	314	73.57	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.06 0.03 - 0.08	0.11 0.05 - 0.17
60–79	264	73.86	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.04 0.02 - 0.06	0.09 0.04 - 0.14

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.4.9b

2,2',4,4',6-Pentabromodiphenyl ether (PBDE 100) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1662	74.07	—	—	<LOD	<LOD	<LOD	3.14 <LOD - 3.88	8.35 6.37 - 10.32	15.09 11.68 - 18.50
20–39	525	72.19	—	—	<LOD	<LOD	<LOD	<LOD	9.08 5.98 - 12.18	17.27 9.53 - 25.01
40–59	594	74.92	—	—	<LOD	<LOD	<LOD	3.17 <LOD - 4.34	7.86 5.70 - 10.02	14.51 8.01 - 21.02
60–79	543	74.95	—	—	<LOD	<LOD	<LOD	3.26 <LOD - 4.21	6.77 4.35 - 9.19	14.59 8.69 - 20.50
Males										
Total, age 20–79	800	73.75	—	—	<LOD	<LOD	<LOD	3.18 <LOD - 4.07	7.51 5.78 - 9.24	13.20 8.64 - 17.76
20–39	240	68.33	—	—	<LOD	<LOD	<LOD	3.31 <LOD - 4.60	8.77 4.20 - 13.33	16.36 <LOD - 31.18
40–59	280	76.43	—	—	<LOD	<LOD	<LOD	3.11 <LOD - 4.29	7.22 4.80 - 9.65	9.51 4.28 - 14.74
60–79	280	75.71	—	—	<LOD	<LOD	<LOD	3.64 <LOD - 5.55	6.85 4.36 - 9.34	12.32 <LOD - 25.29
Females										
Total, age 20–79	862	74.36	—	—	<LOD	<LOD	<LOD	3.12 <LOD - 4.17	8.92 6.12 - 11.73	15.24 10.38 - 20.11
20–39	285	75.44	—	—	<LOD	<LOD	<LOD	<LOD	9.14 4.98 - 13.30	17.77 6.96 - 28.58
40–59	314	73.57	—	—	<LOD	<LOD	<LOD	3.37 <LOD - 4.80	8.75 4.85 - 12.66	15.12 9.16 - 21.08
60–79	263	74.14	—	—	<LOD	<LOD	<LOD	3.19 <LOD - 4.43	6.13 2.38 - 9.88	14.52 8.08 - 20.95

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

8.4.10 2,2',4,4',5,5'-Hexabromodiphenyl Ether (PBDE 153)

■ Table 8.4.10a

2,2',4,4',5,5'-Hexabromodiphenyl ether (PBDE 153)– Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1659	58.65	—	—	<LOD	<LOD	<LOD	0.03 0.03 - 0.04	0.10 0.06 - 0.14	0.22 0.14 - 0.29
20–39	525	54.10	—	—	<LOD	<LOD	<LOD	0.04 0.02 - 0.06	0.13 0.04 - 0.22	0.27 0.17 - 0.37
40–59	592	60.14	—	—	<LOD	<LOD	<LOD	0.03 0.02 - 0.04	0.10 0.06 - 0.14	0.19 0.10 - 0.27
60–79	542	61.44	—	—	<LOD	<LOD	<LOD	0.03 0.03 - 0.03	0.07 0.05 - 0.09	0.19 0.04 - 0.34
Males										
Total, age 20–79	799	52.32	—	—	<LOD	<LOD	<LOD	0.04 0.03 - 0.05	0.13 0.08 - 0.18	0.22 0.11 - 0.33
20–39	240	43.75	—	—	<LOD	<LOD	<LOD	0.06 0.03 - 0.08	0.15 0.06 - 0.24	0.29 0.13 - 0.44
40–59	280	53.57	—	—	<LOD	<LOD	<LOD	0.03 0.02 - 0.04	0.12 0.07 - 0.18	0.20 0.13 - 0.27
60–79	279	58.42	—	—	<LOD	<LOD	<LOD	0.03 0.02 - 0.04	0.07 0.04 - 0.10	0.13 <LOD - 0.31
Females										
Total, age 20–79	860	64.53	—	—	<LOD	<LOD	<LOD	0.03 <LOD - 0.03	0.08 0.03 - 0.13	0.21 0.10 - 0.32
20–39	285	62.81	—	—	<LOD	<LOD	<LOD	0.03 <LOD - 0.04	0.07 <LOD - 0.20	0.24 0.09 - 0.38
40–59	312	66.03	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.09 0.04 - 0.14	0.17 0.03 - 0.31
60–79	263	64.64	—	—	<LOD	<LOD	<LOD	0.03 <LOD - 0.04	0.07 <LOD - 0.12	0.19 <LOD - 0.40

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.4.10b

2,2',4,4',5,5'-Hexabromodiphenyl ether (PBDE 153) (lipid adjusted*) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/kg lipid) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	1657	58.72	—	—	<LOD	<LOD	<LOD	5.37 3.85 - 6.88	16.95 10.13 - 23.77	35.18 22.28 - 48.08
20–39	524	54.20	—	—	<LOD	<LOD	<LOD	7.37 4.06 - 10.68	20.37 6.76 - 33.99	42.23 20.00 - 64.46
40–59	592	60.14	—	—	<LOD	<LOD	<LOD	5.05 3.72 - 6.37	18.37 9.69 - 27.05	28.96 16.66 - 41.27
60–79	541	61.55	—	—	<LOD	<LOD	<LOD	4.39 3.71 - 5.06	11.37 7.27 - 15.48	29.56 8.16 - 50.96
Males										
Total, age 20–79	799	52.32	—	—	<LOD	<LOD	<LOD	7.10 4.82 - 9.37	20.59 13.16 - 28.02	34.88 18.29 - 51.47
20–39	240	43.75	—	—	<LOD	<LOD	<LOD	9.42 5.68 - 13.16	24.88 11.03 - 38.74	42.15 <LOD - 87.64
40–59	280	53.57	—	—	<LOD	<LOD	<LOD	5.66 3.13 - 8.19	20.79 13.47 - 28.12	29.06 19.93 - 38.19
60–79	279	58.42	—	—	<LOD	<LOD	<LOD	4.68 3.30 - 6.06	11.42 5.41 - 17.43	21.58 <LOD - 45.40
Females										
Total, age 20–79	858	64.69	—	—	<LOD	<LOD	<LOD	4.14 <LOD - 5.21	13.63 3.76 - 23.50	34.19 13.20 - 55.19
20–39	284	63.03	—	—	<LOD	<LOD	<LOD	4.39 <LOD - 7.88	14.45 <LOD - 36.75	41.95 12.93 - 70.96
40–59	312	66.03	—	—	<LOD	<LOD	<LOD	3.89 <LOD - 5.51	13.84 2.10 - 25.58	26.99 5.63 - 48.36
60–79	262	64.89	—	—	<LOD	<LOD	<LOD	4.04 <LOD - 5.04	10.71 <LOD - 18.16	33.36 <LOD - 63.57

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

* Lipids were measured in serum, while the chemical was measured in plasma. See Section 6.0, Statistical Data Analysis for further information.

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8.5 PERFLUORINATED COMPOUNDS

Perfluorinated compounds are members of a structurally related class of persistent organic compounds. Characteristic to these compounds is the perfluoroalkyl chain, in which all hydrogen atoms on the carbon backbone are replaced by fluorine atoms. The most extensively studied and measured perfluorinated compounds are the perfluoroalkyl acids perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA). Perfluorohexane sulfonate (PFHxS) is another well-measured perfluoroalkyl acid but it has not been examined to the same extent as PFOS and PFOA.

Perfluorinated compounds do not occur naturally in the environment and have been produced for application in a variety of industrial and commercial uses since the 1950s. The unique fluorine-carbon bond makes these compounds heat stable and able to repel both water and oils. These characteristics make perfluorinated compounds ideal for use in a number of industrial and commercial applications (Kissa, 2001). Perfluorinated compounds are used as stain/water/oil-repellent fabric protectors, in water/oil-repellent paper coatings, wiper blades, bike chain lubricant, wire and cable insulation, pharmaceutical packaging, food packaging, engine oil additives, nail polish, hair-curling and straightening products, metal plating and cleaning, fire retardant foams, inks, and varnishes. They have also been used in polyurethane production and vinyl polymerization. Fluoropolymers manufactured using salts of perfluorinated compounds are used in many industrial and consumer products, including surface coatings on textiles and carpets, in personal care products, and in non-stick coatings on cookware (Kissa, 2001; Prevedouros et al., 2006; INAC, 2009).

PFOS and PFOA are environmentally persistent compounds with a broad use pattern. Entry into the environment occurs through releases during manufacturing and transport, use of consumer products, disposal, and breakdown of other perfluorinated compounds. PFOA, PFOS, and PFHxS have been detected worldwide in wildlife and a wide array of environmental media (Houde et al., 2006). Exposure to the public is widespread; humans may be exposed to perfluoroalkyl acids in food, drinking water, consumer products, dust, soil, and air (Fromme et al., 2007; Fromme et al., 2009; Tittlemier et al., 2007; Holzer et al., 2008; Kubwabo et al., 2005). The contribution of individual pathways and sources of exposure appear to be age dependent with the consumption of contaminated food and drinking water being the primary source of exposure for adults and oral hand-to-mouth contact with consumer products (e.g., carpets, clothing, upholstery) being a significant contributor for infants, toddlers, and children (Trudel et al., 2008).

The perfluoroalkyl acids (PFOS, PFOA, PFHxS) are well absorbed in the body, poorly excreted, and not extensively metabolized (INAC, 2009; Harada et al., 2005; Johnson et al., 1984). Average half-lives in humans range from three to nine years (Olsen et al., 2007). In humans, PFOS and PFOA are distributed to blood serum and plasma, the kidneys, and the liver (Kärrman et al., 2010; Butenhoff et al., 2006). The perfluoroalkyl acids have a strong affinity for the protein fraction in blood and do not typically accumulate in lipids (Kärrman et al., 2010; Martin et al., 2004). Perfluoroalkyl acids are commonly measured in serum and plasma and similar levels are found in these two biological media based on validation studies (Ehresman et al., 2007). Perfluoroalkyl acids have also been measured in liver tissue, whole blood, breast milk, and umbilical cord blood in humans (Olsen et al., 2003; Fromme et al., 2009; Monroy et al., 2008; Kärrman et al., 2010). Although PFOA and PFOS are environmentally persistent, not well metabolized, and have relatively long half-lives in humans, age-related increases in serum levels have not been seen in most studies in contrast to what is seen with lipophilic persistent organic pollutants (Fromme et al. 2007; Calafat et al., 2007a). Serum concentrations of some perfluoroalkyl acids in children appear to be higher than in adults and may be related to differences in sources and routes of exposure between these two age groups (Calafat et al., 2007a; Calafat et al., 2007b; Kato et al., 2009).

The primary concern with perfluoroalkyl acids is their persistence in both the environment and the human body (Olsen et al., 2007). No definitive links between exposure to these substances and human health effects have been established based on occupational studies or studies of populations exposed to contaminated drinking water; however, adverse effects have been observed in animals (Calafat et al., 2007b). The liver is the primary target organ of toxicity for PFOS and PFOA in several animal species (Health Canada, 2006; INAC, 2009;

US EPA, 2002). Both PFOS and PFOA have evidence of developmental toxicity and carcinogenicity in animals (Trudel et al., 2008; Health Canada, 2006).

Worldwide use of PFOS and PFOS-based products has decreased significantly since 2002 when the world's largest producer of PFOS at the time voluntarily agreed to phase out this compound from various formulations. PFHxS, a known by-product in the process used in the production of these compounds, was also phased out as a result. There is no known current production of PFOS and PFHxS in North America (US EPA, 2000). Following assessment by Environment Canada and Health Canada in 2006, PFOS and its salts were concluded to be of concern to the environment. In 2009, PFOS and its salts were added to the Virtual Elimination List, which is mandated under Section 65(3) of CEPA 1999. Canada is working through the United Nations Economic Commission for Europe (UNECE) Convention on Long-range Transboundary Air Pollution (LRTAP) and the Stockholm Convention on Persistent Organic Pollutants to reduce the global production of PFOS (Government of Canada, 2009).

There is a global initiative to reduce PFOA emissions and product content. In 2006, the United States Environmental Protection Agency and eight major companies in the industry launched the 2010–15 PFOA Stewardship Program, in which companies committed to reduce global facility emissions and product content of PFOA and related chemicals by 95% by 2010, and to work toward eliminating emissions and product content by 2015 (US EPA, 2009). In Canada, an Environmental Performance Agreement on perfluorinated compounds and their precursors was signed by four companies in Canada. The Agreement is consistent with targets and commitments by industry in the United States (Environment Canada, 2010). An assessment of PFOA will be released by Environment Canada and Health Canada in 2010.

Perfluoroalkyl acids have been measured in the serum of Canadians. In 2002, serum samples from 56 individuals in Ottawa–Gatineau were analyzed for PFOS and PFOA. PFOS was reported in all samples with a mean concentration of 28.8 µg/L and a range of 3.7 to 65.1 µg/L. The concentration of PFOA was considerably lower, with a mean of 3.4 µg/L and a range from <1.2 to 7.2 µg/L (Kubwabo et al., 2004). In 2004–2005, perfluoroalkyl acids were measured in a study of pregnant women and their babies in Hamilton, Ontario. PFOS was detected in all 101 maternal serum samples, with mean levels of 18.3 µg/L at 24–28 weeks gestation, and 16.2 µg/L at delivery; and in all 105 umbilical cord serum samples with a mean of 7.2 µg/L. PFOA was detected in all 101 maternal serum samples, with mean levels of 2.5 µg/L at 24–28 weeks gestation, and 2.2 µg/L at delivery; and in all 105 umbilical cord serum samples with a mean of 1.9 µg/L. PFHxS was detected in approximately 45% of maternal serum samples, with mean levels of 4.1 µg/L at 24–28 weeks gestation, and 4.0 µg/L at delivery; and 20% of umbilical cord serum samples with a mean of 5.0 µg/L (Monroy et al., 2008). Perfluoroalkyl acids were measured in serum from 252 pregnant women collected from 2005–2006 in Alberta. PFOS ranged from <LOD to 35 µg/L (median 7.8 µg/L), PFOA concentrations ranged from <LOD to 18 µg/L (median 1.5 µg/L), and PFHxS ranged from <LOD to 43 µg/L (median 0.97 µg/L) and (Hamm et al., 2009).

Perfluoroalkyl acids have been measured in pooled serum or plasma in multiple studies in Canada. Perfluoroalkyl acids were measured in 23 pooled samples of maternal serum and cord blood collected from 1994 to 2001 from various northern Canadian populations. The arithmetic means of PFOS levels in pooled maternal and cord blood were 36.9 and 16.7 µg/L, respectively. The arithmetic mean PFOA concentrations in pooled maternal and cord plasma were 2.2 and 3.4 µg/L, respectively (Tittlemier et al., 2004). Perfluoroalkyl acids were measured in pooled serum from 50,599 pregnant women in Alberta in 2005 as part of the Alberta Biomonitoring Program. Levels of PFOS, PFOA, and PFHxS ranged from 0.3–14, 1.7–3.8, and 0.7–9.8 ng/g serum, respectively (Alberta Health and Wellness, 2008).

PFOS, PFOA, and PFHxS were measured in plasma of a subset of the population aged 20–79 years participating in the Canadian Health Measures Survey and are presented as µg/L plasma (Tables 8.5.1a, 8.5.2a, 8.5.3a). Participants were selected within the specified age range to be a representative sample of the Canadian population. Finding a measurable amount of perfluoroalkyl acids in plasma is an indicator of exposure to perfluoroalkyl acids and does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for plasma levels of perfluoroalkyl acids in the Canadian population.

8.5.1 Perfluorooctane Sulfonate (PFOS) (CASRN 1763-23-1)

■ Table 8.5.1a

Perfluorooctane Sulfonate (PFOS) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	2880	0.14	11.31 10.02 - 12.60	8.85 7.97 - 9.82	3.62 3.08 - 4.16	5.71 5.01 - 6.40	9.17 8.08 - 10.25	13.89 12.34 - 15.44	19.81 16.92 - 22.69	27.53 22.77 - 32.29
20–39	979	0.10	10.21 9.03 - 11.40	8.16 7.13 - 9.33	3.47 2.77 - 4.16	5.43 4.60 - 6.25	8.62 7.32 - 9.93	12.90 11.28 - 14.51	17.19 15.56 - 18.83	21.84 19.11 - 24.57
40–59	983	0.31	11.15 9.42 - 12.89	8.56 7.69 - 9.54	3.43 2.84 - 4.01	5.52 4.84 - 6.19	8.89 7.97 - 9.81	13.62 11.47 - 15.77	19.20 14.21 - 24.19	28.59 19.90 - 37.28
60–79	918	0.00	13.63 11.82 - 15.43	10.95 9.58 - 12.51	4.43 3.37 - 5.50	7.79 6.64 - 8.94	11.63 10.00 - 13.25	16.93 14.21 - 19.64	25.00 21.21 - 28.79	30.21 24.52 - 35.89
Males										
Total, age 20–79	1376	0.07	13.81 11.96 - 15.66	11.13 10.03 - 12.36	5.19 4.33 - 6.05	7.67 6.72 - 8.63	11.28 9.90 - 12.65	16.48 14.66 - 18.30	23.67 18.16 - 29.18	31.31 23.68 - 38.94
20–39	435	0.00	12.67 11.01 - 14.34	10.44 9.16 - 11.88	5.27 4.35 - 6.18	7.66 6.22 - 9.11	10.69 9.36 - 12.02	14.81 13.08 - 16.54	20.23 17.75 - 22.71	27.55 19.75 - 35.36
40–59	480	0.21	14.29 11.26 - 17.33	11.35 10.08 - 12.77	4.99 3.97 - 6.01	7.25 6.49 - 8.01	11.26 9.59 - 12.92	16.83 14.69 - 18.97	27.78 16.91 - 38.65	34.20 22.60 - 45.81
60–79	461	0.00	15.01 12.71 - 17.30	12.11 10.47 - 14.00	4.99 3.01 - 6.96	8.45 7.22 - 9.69	12.41 10.06 - 14.76	18.30 14.32 - 22.28	26.94 21.58 - 32.31	34.95 23.77 - 46.13
Females										
Total, age 20–79	1504	0.20	8.86 7.83 - 9.89	7.07 6.30 - 7.93	3.08 2.68 - 3.47	4.51 3.96 - 5.06	7.42 6.45 - 8.39	11.24 9.84 - 12.64	15.98 14.05 - 17.91	20.05 15.85 - 24.25
20–39	544	0.18	7.73 6.57 - 8.88	6.36 5.37 - 7.53	3.08 2.68 - 3.47	4.35 3.62 - 5.08	6.42 5.16 - 7.69	9.89 7.26 - 12.52	13.98 11.57 - 16.40	16.69 14.10 - 19.28
40–59	503	0.40	8.05 7.04 - 9.06	6.48 5.75 - 7.30	2.82 2.24 - 3.39	4.21 3.56 - 4.87	6.99 5.99 - 7.98	10.25 9.21 - 11.28	13.86 11.27 - 16.45	16.99 11.57 - 22.42
60–79	457	0.00	12.37 10.78 - 13.96	9.99 8.67 - 11.52	4.15 3.12 - 5.17	6.91 5.33 - 8.48	10.86 9.09 - 12.62	15.00 12.37 - 17.63	22.41 18.91 - 25.90	27.29 22.87 - 31.71

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

8.5.2 Perfluorooctanoic Acid (PFOA) (CASRN 335-67-1)

■ Table 8.5.2a

Perfluorooctanoic Acid (PFOA) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	2880	1.11	2.89 2.72 - 3.07	2.52 2.36 - 2.69	1.32 1.20 - 1.45	1.90 1.78 - 2.02	2.66 2.46 - 2.86	3.62 3.41 - 3.83	4.69 4.35 - 5.02	5.50 5.16 - 5.84
20–39	979	1.12	2.81 2.58 - 3.03	2.43 2.24 - 2.65	1.20 0.99 - 1.42	1.84 1.67 - 2.02	2.58 2.33 - 2.84	3.61 3.31 - 3.91	4.59 4.06 - 5.11	5.40 4.84 - 5.96
40–59	983	1.02	2.83 2.63 - 3.04	2.49 2.31 - 2.68	1.34 1.19 - 1.49	1.86 1.71 - 2.02	2.60 2.38 - 2.83	3.49 3.26 - 3.71	4.54 4.10 - 4.97	5.42 4.67 - 6.18
60–79	918	1.20	3.18 2.94 - 3.42	2.75 2.49 - 3.03	1.51 1.28 - 1.75	2.12 1.93 - 2.31	2.87 2.66 - 3.08	3.99 3.56 - 4.42	5.21 4.70 - 5.73	6.27 5.48 - 7.07
Males										
Total, age 20–79	1376	0.51	3.26 3.05 - 3.48	2.94 2.74 - 3.15	1.63 1.46 - 1.80	2.25 2.05 - 2.44	3.11 2.86 - 3.36	4.10 3.78 - 4.42	5.01 4.51 - 5.52	5.98 5.48 - 6.47
20–39	435	0.00	3.37 3.08 - 3.65	3.08 2.83 - 3.36	1.75 1.51 - 1.99	2.35 2.10 - 2.60	3.27 3.02 - 3.52	4.11 3.72 - 4.50	5.35 4.62 - 6.08	5.87 5.14 - 6.60
40–59	480	0.42	3.16 2.91 - 3.41	2.86 2.62 - 3.11	1.57 1.37 - 1.78	2.15 1.89 - 2.41	3.00 2.69 - 3.30	3.89 3.48 - 4.30	4.77 4.29 - 5.25	5.69 4.86 - 6.52
60–79	461	1.08	3.27 2.92 - 3.61	2.83 2.52 - 3.17	1.53 1.25 - 1.81	2.15 1.89 - 2.40	2.96 2.65 - 3.28	4.16 3.58 - 4.74	5.38 4.61 - 6.16	6.48 5.30 - 7.66
Females										
Total, age 20–79	1504	1.66	2.53 2.37 - 2.70	2.17 1.99 - 2.36	1.10 0.96 - 1.24	1.63 1.47 - 1.76	2.28 2.09 - 2.46	3.13 2.93 - 3.32	4.20 3.82 - 4.58	4.99 4.46 - 5.51
20–39	544	2.02	2.24 2.03 - 2.45	1.92 1.70 - 2.15	0.95 0.75 - 1.16	1.45 1.25 - 1.64	2.10 1.88 - 2.31	2.82 2.51 - 3.13	3.76 3.35 - 4.18	4.31 3.72 - 4.90
40–59	503	1.59	2.51 2.28 - 2.73	2.17 1.97 - 2.40	1.14 0.93 - 1.36	1.62 1.42 - 1.82	2.22 2.00 - 2.44	3.04 2.82 - 3.26	3.99 3.42 - 4.56	4.95 4.13 - 5.77
60–79	457	1.31	3.10 2.90 - 3.30	2.68 2.43 - 2.95	1.51 1.24 - 1.78	2.06 1.84 - 2.29	2.76 2.57 - 2.94	3.76 3.35 - 4.18	4.90 4.50 - 5.30	6.09 5.40 - 6.77

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

8.5.3 Perfluorohexane Sulfonate (PFHxS) (CASRN 355-46-4)

Table 8.5.3a

Perfluorohexane Sulfonate (PFHxS) – Arithmetic and geometric means, and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 20–79	2880	2.05	3.87 3.25 - 4.48	2.26 1.97 - 2.59	0.74 0.60 - 0.88	1.27 1.09 - 1.45	2.22 1.88 - 2.56	3.74 3.28 - 4.19	7.36 6.64 - 8.07	12.49 9.66 - 15.32
20–39	979	3.06	4.26 3.11 - 5.41	2.07 1.79 - 2.39	0.65 0.55 - 0.76	1.10 0.93 - 1.27	1.92 1.56 - 2.27	3.59 3.21 - 3.96	7.95 5.38 - 10.52	16.70 9.86 - 23.54
40–59	983	2.03	3.36 3.02 - 3.70	2.19 1.91 - 2.53	0.76 0.60 - 0.91	1.26 1.03 - 1.50	2.21 1.87 - 2.55	3.65 3.01 - 4.29	6.91 6.27 - 7.55	9.25 7.38 - 11.12
60–79	918	0.98	4.16 3.44 - 4.88	2.80 2.38 - 3.30	1.13 0.93 - 1.33	1.70 1.41 - 1.98	2.60 2.18 - 3.02	4.34 3.50 - 5.17	8.50 6.32 - 10.68	12.64 9.11 - 16.17
Males										
Total, age 20–79	1376	0.58	5.04 4.14 - 5.94	3.23 2.83 - 3.68	1.35 1.12 - 1.58	1.92 1.62 - 2.23	2.89 2.47 - 3.31	4.63 4.02 - 5.24	9.26 7.42 - 11.09	15.92 11.26 - 20.59
20–39	435	0.23	6.16 3.91 - 8.41	3.34 2.70 - 4.13	1.30 0.96 - 1.63	1.78 1.47 - 2.09	2.81 2.35 - 3.27	4.69 3.27 - 6.11	13.01 4.51 - 21.51	23.98 6.07 - 41.89
40–59	480	0.42	4.46 3.91 - 5.02	3.26 2.80 - 3.80	1.46 1.16 - 1.75	2.10 1.63 - 2.58	2.92 2.42 - 3.43	4.81 3.52 - 6.11	7.83 6.40 - 9.25	11.10 5.83 - 16.37
60–79	461	1.08	4.07 3.37 - 4.78	2.96 2.52 - 3.48	1.24 1.00 - 1.48	1.93 1.65 - 2.20	2.78 2.20 - 3.35	4.39 3.68 - 5.10	7.66 4.37 - 10.96	12.52 9.05 - 16.00
Females										
Total, age 20–79	1504	3.39	2.72 2.23 - 3.21	1.59 1.36 - 1.86	0.55 0.43 - 0.67	0.91 0.77 - 1.04	1.52 1.26 - 1.78	2.68 2.26 - 3.11	5.31 3.91 - 6.71	8.52 6.57 - 10.47
20–39	544	5.33	2.34 1.65 - 3.03	1.28 1.07 - 1.53	0.41 <LOD - 0.62	0.75 0.59 - 0.91	1.22 1.08 - 1.36	2.17 1.49 - 2.84	4.33 3.67 - 5.00	8.99 4.64 - 13.33
40–59	503	3.58	2.27 1.81 - 2.73	1.48 1.24 - 1.77	0.52 0.38 - 0.67	0.88 0.76 - 1.00	1.45 1.14 - 1.75	2.53 2.16 - 2.90	4.58 2.97 - 6.20	6.68 4.94 - 8.41
60–79	457	0.88	4.24 3.24 - 5.23	2.67 2.20 - 3.24	1.08 0.79 - 1.36	1.56 1.32 - 1.80	2.40 1.97 - 2.83	3.96 2.68 - 5.25	8.52 6.08 - 10.96	13.26 6.71 - 19.81

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.6 ENVIRONMENTAL PHENOL

8.6.1 Bisphenol A (CASRN 80-05-7)

Bisphenol A (BPA), or phenol, 4,4'-(1-methylethylidene) bis-, is a chemical monomer used in the production of polycarbonate and as a precursor for monomers of certain epoxy-phenolic resins. Polycarbonate is used in the manufacture of food and beverage containers (e.g., repeat-use water bottles, storage containers, and infant bottles) and epoxy resins are used as an interior protective lining for food and beverage cans (including those for ready-to-use, concentrate, and powdered infant formula). Plastics and resins made from bisphenol A can also be used in a range of other products including medical devices (e.g., blood oxygenators, incubators, and respiratory devices), some dental fillings and sealants, sporting and safety equipment (e.g., hockey helmets), electronics (e.g., alarm devices, mobile phone housings, and computers), and automotive parts (e.g., headlights, bumpers, and inside lights) (NTP, 2007; EFSA, 2006).

The primary route of exposure to BPA for the public is through dietary intake (e.g., migration from food packaging, migration from repeat-use polycarbonate containers). Exposure can also occur from contact with environmental media (i.e., ambient air, indoor air, drinking water, soil, and dust) and from the use of consumer products and other sources. In Canada, exposure estimates for the general population range from 0.08 to 4.30 µg/kg body weight/day. In infants less than 18 months of age, the most highly exposed sub-population, exposure estimates ranged from 0.27 to 4.30 µg/kg body weight/day (Health Canada, 2008a).

Glucuronidation has been recognized as a major metabolic pathway for BPA in various species, including humans (EFSA, 2008; USFDA, 2008). In humans, BPA administered orally undergoes first-pass metabolism in the gut wall and the liver, where it is quickly biotransformed into the major metabolite BPA-monoglucuronide (BPA-G). This metabolite lacks endocrine activity and is rapidly excreted in urine with a half-life of less than six hours (Tominaga et al., 2006; Volkel et al., 2002). Free BPA, not the glucuronide conjugate, is considered to be the biologically active moeity (Health Canada, 2008a).

Urinary concentration of BPA can be used as a biomarker of exposure. The urinary distribution of free and conjugated species of BPA may provide valuable information for exposure assessment and risk assessment (Ye et al., 2005). The frequent use of BPA-containing products in the laboratory, during the sampling process or for subsequent handling, results in background contamination of samples, making it difficult to determine whether observed levels of free BPA represent real exposure (either from un-metabolized BPA or from breakdown of unstable BPA-G to free BPA) or from background contamination (Ye et al, 2007; Waechter et al, 2007; Volkel et al., 2008). Some studies have successfully excluded the free form of BPA in the analysis to eliminate potential contamination from sampling or laboratory handling and quantified the conjugated forms of urinary BPA; however, due to instability of the BPA-G when stored at room temperature, exclusion of the free form BPA could underestimate exposure to BPA (Yang et al., 2003; Ye et al., 2007).

The European Chemicals Bureau has classified BPA as a Category 3 reproductive toxicant, that is, a substance that causes concern for human fertility based on sufficient evidence of reproductive toxicity in laboratory animals (ECB, 2003). In 1999, Health Canada concluded that there was sufficient evidence to describe BPA as an endocrine disrupter, but it was noted that some estrogenic effects were not repeatable under similar conditions in different laboratories (Health Canada, 2008b). BPA is considered to be a weak environmental estrogen based on traditional bioassays; however, evidence suggests that BPA can stimulate cellular responses at very low concentrations (Health Canada, 2008a). BPA is acutely toxic to aquatic organisms and has been shown to adversely affect growth and development in both aquatic and terrestrial species. There is evidence to suggest that low-level exposure to BPA, particularly at sensitive life-cycle stages, may lead to persistent alterations in hormonal, developmental, metabolic, and/or reproductive processes later in life (Health Canada, 2008a).

The key effects considered by Health Canada as appropriate departure points for the characterization of risk to human health from exposure to BPA involve the liver and reproductive system, including effects on fertility and development (ECB, 2003; Health Canada, 2008a). Developmental neurotoxicity studies in rodents have suggested that at levels of exposure well below those established for reproductive and developmental effects, BPA can affect neural development and behaviour when laboratory animals are exposed *in utero* or very early in life (Health Canada, 2008a). The potential role of BPA and other environmental estrogens in the prevalence of obesity and related metabolic diseases, as well as certain types of cancer, is under intensive debate and investigation among scientific communities (Newbold et al., 2009; Ben-Jonathan et al., 2009; Soto et al., 2008).

The toxicokinetics and metabolism of BPA in pregnant animals, fetuses, and neonates may be different than in non-pregnant adult animals (Health Canada, 2008a). Some data indicate that repeated maternal exposure in humans could lead to an accumulation of fetal circulating levels of free BPA and correspondingly elevated *in utero* exposures (Ikezuki et al., 2002; Welshons et al., 2006). Taken together, the differences in toxicokinetics and metabolism suggest that the developing fetus or neonate may be more sensitive to BPA. In the absence of a fully developed, physiologically based pharmacokinetic model, it is appropriate to consider the pregnant woman/fetus and infant as potentially sensitive subpopulations (Health Canada, 2008a).

Health Canada has conducted a scientific screening assessment of the impact of human and environmental exposure to BPA and determined that it is of concern to human health and the environment as per the criteria set out under the *Canadian Environmental Protection Act, 1999* (Government of Canada, 2009). Combining the highest potential exposure and potential vulnerability, the risk management focused on decreasing exposure to newborns and infants. A prohibition of polycarbonate baby bottles that contain BPA came into force on March 11, 2010, and was published in the *Canada Gazette*, Part II, on March 31, 2010. Part I of Schedule I to the *Hazardous Products Act* was amended to include polycarbonate baby bottles that contain BPA, thus prohibiting the advertisement, sale and importation in Canada of these products (Government of Canada, 2010).

Based on the overall weight of evidence, Health Canada has concluded that the current dietary exposure to BPA through food packaging is not expected to pose a health risk to the general population, including newborns and infants. A provisional tolerable daily intake for BPA of 25 μg/kg body weight/day, based solely on dietary exposure through food packaging, was established in 1996 by the Food Directorate of Health Canada, and was reaffirmed for the general population in 2008 (Health Canada, 2008b).

With respect to risk management strategies to address BPA in food, Health Canada is committed to supporting industry in developing a "Code of Practice" to reduce levels of BPA in infant formula and general food can linings. Health Canada, the US FDA and industry have met to initiate this process. Health Canada has committed to facilitating the assessment of proposed industry alternatives to BPA for use in infant formula and general food can linings, as well as setting stringent migration targets for BPA in infant formula cans. Migration targets for canned foods, in general, will be explored. Finally, Health Canada will continue to review pre-market submissions for infant formula packaging, to ensure the lowest levels of BPA achievable.

Urinary total (free + conjugated) BPA was measured in all Canadian Health Measures Survey participants aged 6–79 years and is presented as μg/L urine and μg/g creatinine (Tables 8.6.1a, 8.6.1b). Finding a measurable amount of BPA in urine does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for urinary levels of total (free + conjugated) BPA in the Canadian population.

Table 8.6.1a

Bisphenol A – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5476	9.26	2.31 2.08 - 2.54	1.16 1.08 - 1.24	<LOD <LOD - 0.34	0.60 0.53 - 0.66	1.33 1.17 - 1.49	2.56 2.28 - 2.84	4.62 4.09 - 5.15	7.01 5.68 - 8.33
6–11	1031	6.79	2.58 2.10 - 3.06	1.30 1.17 - 1.45	0.32 0.22 - 0.42	0.69 0.58 - 0.81	1.39 1.15 - 1.64	2.65 2.28 - 3.01	4.51 3.88 - 5.13	7.16 5.56 - 8.76
12–19	980	6.22	2.65 2.23 - 3.06	1.50 1.28 - 1.77	0.34 0.27 - 0.41	0.80 0.59 - 1.00	1.68 1.38 - 1.97	3.00 2.31 - 3.70	5.90 4.78 - 7.02	8.40 6.22 - 10.58
20–39	1165	8.84	2.71 2.23 - 3.18	1.33 1.18 - 1.49	0.29 <LOD - 0.46	0.68 0.52 - 0.85	1.48 1.29 - 1.67	2.83 2.52 - 3.15	4.80 4.18 - 5.42	7.30 5.17 - 9.43
40–59	1219	12.06	2.07 1.77 - 2.38	1.04 0.96 - 1.12	<LOD	0.50 0.42 - 0.57	1.26 1.13 - 1.40	2.46 2.05 - 2.87	4.40 3.51 - 5.30	6.58 4.81 - 8.36
60–79	1081	11.66	1.74 1.53 - 1.95	0.90 0.82 - 0.99	<LOD	0.46 0.40 - 0.52	1.00 0.84 - 1.16	1.89 1.56 - 2.23	3.78 3.33 - 4.24	5.22 3.83 - 6.60
Males										
Total, age 6–79	2659	7.67	2.42 2.09 - 2.76	1.29 1.20 - 1.38	0.29 <LOD - 0.40	0.71 0.62 - 0.81	1.43 1.26 - 1.59	2.66 2.33 - 3.00	4.48 3.91 - 5.05	6.77 5.37 - 8.18
6–11	524	6.11	2.30 1.95 - 2.64	1.27 1.07 - 1.52	0.38 0.26 - 0.49	0.67 0.49 - 0.85	1.38 1.10 - 1.66	2.55 2.15 - 2.94	4.20 3.40 - 5.00	6.79 4.69 - 8.88
12–19	504	5.56	2.45 1.84 - 3.06	1.44 1.15 - 1.81	0.38 0.24 - 0.52	0.83 0.58 - 1.08	1.60 1.22 - 1.99	2.76 2.12 - 3.41	5.62 3.48 - 7.76	8.20 5.58 - 10.82
20–39	513	7.60	2.79 2.02 - 3.56	1.40 1.24 - 1.58	0.33 <LOD - 0.50	0.73 0.52 - 0.94	1.57 1.29 - 1.85	2.89 2.60 - 3.19	4.55 3.88 - 5.22	6.55 4.97 - 8.13
40–59	577	9.01	2.33 1.92 - 2.74	1.25 1.13 - 1.39	<LOD <LOD - 0.40	0.75 0.63 - 0.87	1.40 1.21 - 1.59	2.60 2.17 - 3.03	4.21 3.23 - 5.19	6.41 4.29 - 8.54
60–79	541	9.80	1.97 1.63 - 2.30	1.08 0.94 - 1.24	0.23 <LOD - 0.35	0.53 0.36 - 0.70	1.23 1.03 - 1.42	2.16 1.80 - 2.53	3.98 3.40 - 4.56	5.92 4.04 - 7.81
Females										
Total, age 6–79	2817	10.76	2.20 1.92 - 2.48	1.04 0.94 - 1.16	<LOD	0.49 0.42 - 0.57	1.17 0.99 - 1.35	2.41 2.08 - 2.75	4.90 4.25 - 5.55	7.04 5.40 - 8.68
6–11	507	7.50	2.88 1.77 - 3.99	1.33 1.09 - 1.61	0.30 0.21 - 0.39	0.70 0.58 - 0.82	1.42 1.02 - 1.81	2.79 2.14 - 3.43	4.87 3.93 - 5.81	7.52 5.43 - 9.62
12–19	476	6.93	2.86 2.43 - 3.29	1.57 1.29 - 1.92	0.30 <LOD - 0.41	0.79 0.50 - 1.08	1.83 1.47 - 2.19	3.87 3.16 - 4.57	6.47 5.15 - 7.79	8.10 5.44 - 10.76
20–39	652	9.82	2.62 2.08 - 3.16	1.26 1.06 - 1.49	0.25 <LOD - 0.46	0.64 0.48 - 0.81	1.41 1.17 - 1.66	2.73 2.18 - 3.28	5.07 3.79 - 6.35	8.08 4.98 - 11.19
40–59	642	14.80	1.82 1.55 - 2.08	0.86 0.77 - 0.96	<LOD	0.36 0.28 - 0.45	1.02 0.84 - 1.20	2.04 1.58 - 2.50	4.71 3.40 - 6.02	6.61 4.66 - 8.56
60–79	540	13.52	1.53 1.23 - 1.83	0.76 0.65 - 0.88	<LOD	0.40 0.29 - 0.50	0.80 0.63 - 0.97	1.64 1.33 - 1.95	3.42 2.49 - 4.35	4.88 3.54 - 6.23

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.6.1b

Bisphenol A (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5462	9.28	2.51 2.27 - 2.75	1.40 1.32 - 1.49	<LOD <LOD - 0.49	0.79 0.72 - 0.86	1.39 1.27 - 1.50	2.50 2.26 - 2.75	4.74 4.08 - 5.41	7.23 6.45 - 8.01
6–11	1028	6.81	3.45 2.83 - 4.07	2.00 1.79 - 2.23	0.65 0.54 - 0.76	1.14 0.99 - 1.29	1.94 1.64 - 2.23	3.54 2.93 - 4.15	5.99 4.85 - 7.13	9.80 7.29 - 12.31
12–19	978	6.24	2.28 1.91 - 2.65	1.31 1.17 - 1.46	0.42 0.35 - 0.49	0.75 0.63 - 0.86	1.27 1.09 - 1.44	2.31 1.89 - 2.74	4.23 3.37 - 5.09	6.43 4.03 - 8.83
20–39	1161	8.87	2.67 2.25 - 3.08	1.49 1.41 - 1.57	0.44 <LOD - 0.54	0.87 0.79 - 0.95	1.47 1.32 - 1.62	2.61 2.39 - 2.83	4.39 3.38 - 5.39	6.83 5.93 - 7.73
40–59	1214	12.11	2.37 2.05 - 2.68	1.33 1.20 - 1.47	<LOD	0.76 0.61 - 0.91	1.34 1.20 - 1.47	2.35 1.96 - 2.74	4.74 3.79 - 5.69	7.45 6.13 - 8.78
60–79	1081	11.66	2.25 1.91 - 2.59	1.26 1.14 - 1.40	<LOD	0.68 0.60 - 0.76	1.27 1.15 - 1.38	2.31 1.91 - 2.72	4.28 2.97 - 5.58	7.63 5.40 - 9.86
Males										
Total, age 6–79	2650	7.70	2.19 1.98 - 2.40	1.28 1.18 - 1.38	0.41 <LOD - 0.50	0.72 0.65 - 0.79	1.29 1.17 - 1.41	2.29 1.99 - 2.59	3.93 3.51 - 4.34	6.08 5.32 - 6.85
6–11	522	6.13	3.06 2.55 - 3.57	1.93 1.75 - 2.13	0.65 0.50 - 0.79	1.17 0.99 - 1.35	1.99 1.67 - 2.30	3.31 2.71 - 3.91	5.24 4.12 - 6.35	7.88 5.61 - 10.14
12–19	503	5.57	1.93 1.52 - 2.35	1.22 1.02 - 1.45	0.41 0.33 - 0.49	0.71 0.54 - 0.89	1.17 1.00 - 1.35	2.14 1.56 - 2.71	4.04 3.31 - 4.77	5.78 2.64 - 8.92
20–39	511	7.63	2.25 1.73 - 2.76	1.30 1.17 - 1.45	0.44 <LOD - 0.53	0.75 0.64 - 0.85	1.32 1.07 - 1.58	2.28 1.85 - 2.71	3.75 3.06 - 4.43	5.08 4.12 - 6.03
40–59	573	9.08	2.16 1.70 - 2.62	1.23 1.08 - 1.40	<LOD <LOD - 0.50	0.69 0.56 - 0.82	1.27 1.13 - 1.41	2.17 1.68 - 2.66	3.75 2.82 - 4.67	6.19 4.60 - 7.79
60–79	541	9.80	1.93 1.71 - 2.16	1.14 1.02 - 1.27	0.32 <LOD - 0.43	0.64 0.55 - 0.74	1.22 1.09 - 1.36	2.06 1.76 - 2.35	3.76 2.52 - 5.00	5.96 4.47 - 7.45
Females										
Total, age 6–79	2812	10.78	2.83 2.51 - 3.14	1.54 1.44 - 1.64	<LOD	0.88 0.82 - 0.94	1.51 1.39 - 1.63	2.79 2.43 - 3.15	5.86 4.92 - 6.80	8.59 6.98 - 10.19
6–11	506	7.51	3.86 2.67 - 5.06	2.08 1.77 - 2.45	0.65 0.51 - 0.79	1.12 0.94 - 1.30	1.90 1.58 - 2.23	3.77 2.89 - 4.64	6.68 4.82 - 8.55	11.89 6.33 - 17.44
12–19	475	6.95	2.65 1.98 - 3.33	1.41 1.28 - 1.56	0.45 <LOD - 0.55	0.79 0.69 - 0.90	1.43 1.20 - 1.67	2.50 2.04 - 2.95	4.81 3.02 - 6.60	6.68 1.72 - 11.63
20–39	650	9.85	3.09 2.49 - 3.68	1.70 1.53 - 1.89	0.50 <LOD - 0.64	1.02 0.87 - 1.16	1.58 1.27 - 1.88	2.93 2.56 - 3.30	6.08 5.13 - 7.03	7.87 5.78 - 9.95
40–59	641	14.82	2.57 2.17 - 2.98	1.43 1.27 - 1.62	<LOD	0.82 0.61 - 1.03	1.40 1.20 - 1.61	2.67 1.94 - 3.39	5.77 4.15 - 7.39	8.79 5.46 - 12.13
60–79	540	13.52	2.54 2.00 - 3.08	1.39 1.23 - 1.56	<LOD	0.72 0.61 - 0.82	1.40 1.22 - 1.58	2.44 1.78 - 3.09	4.89 2.30 - 7.47	8.89 4.92 - 12.86

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.7 ORGANOPHOSPHATE INSECTICIDES (METABOLITES)

Organophosphate pesticides are a group of closely related insecticides that is used extensively in agriculture in Canada, as well as in the home, the garden, and veterinary practice. This class of pesticides gained popularity in use as the organochlorine pesticides were banned in the 1970s. Organophosphate pesticides are less persistent in the environment and less susceptible to pest resistance than the organochlorine pesticides; however, concerns remain over their relatively high acute toxicity (Wessels et al., 2003). Nineteen organophosphate pesticides were registered for use in Canada during the sampling period of the Canadian Health Measures Survey (CHMS) (2007–2009), namely acephate, azinphos-methyl, bensulide, chlorpyrifos, coumaphos, diazinon, dichlorvos, dimethoate, fenthion, malathion, methamidophos, naled, phorate, phosalone, phosmet, propetamphos, terbufos, tetrachlorvinphos, and trichlorfon. These pesticides are marketed under various trade names.

Organophosphate pesticides have been linked to naturally occurring compounds produced by algae and bacteria; however, their presence in the environment is almost exclusively due to their anthropogenic use as pesticides (Neumann & Peter, 1987). Their ability to degrade made them an attractive alternative to the persistent organochlorine pesticides, such as DDT and mirex.

Organophosphate pesticides have both agricultural and residential uses, ranging from spraying over large-scale areas to individual use within homes. Major uses include as an insecticide on food and feed crops, livestock, and ornamental plants; for insect control in food storage areas, greenhouses, forestry structures, and seed treatment; for control of pet parasites; and mosquito control (Health Canada, 2009a, 2009b). Although the majority of organophosphates are used as insecticides, bensulide is used as a selective herbicide for the control of weeds in turf and cucumbers. In addition to the pesticide uses, dichlorvos and trichlorfon have veterinary drug uses for the control of parasites in livestock (Health Canada, 2009c).

The primary routes of exposure for the public are through ingestion of food previously treated with organophosphate pesticides and from drinking water contaminated with agricultural runoff (ATSDR, 1997a, 1997b, 2003). Other means of exposure include dermal and inhalation exposure during use of products containing organophosphates or entry into areas previously treated with organophosphates. Despite their rapid degradation in the environment, small amounts can be detected in food and drinking water.

After entry into the body, organophosphate pesticides are rapidly metabolized and excreted in urine (Barr & Needham, 2002). Hydrolysis of ester linkages in the parent compound yields dialkyl phosphate metabolites, which are common metabolites of the majority of organophosphates. These metabolites also occur in the environment following degradation of the parent compound. Dialkyl phosphate metabolites are not considered toxic, but are considered to be biomarkers of exposure to the parent pesticides and also reflect exposure to the metabolite in the environment (EPA, 1999; CDC, 2005). The dialkyl phosphate metabolites are not pesticide-specific; rather, each is associated with several organophosphate pesticides, and many organophosphates can form more than one of these metabolites. Not all organophosphates break down into dialkyl phosphate metabolites, including acephate and methamidophos (Barr & Needham, 2002; Wessels et al., 2003). In addition to the dialkyl phosphate metabolites, organophosphate parent compounds and other breakdown products can be measured in blood and urine; detection is generally believed to reflect exposures over the previous few days (EPA, 1999; CDC, 2005). There are six dialkyl phosphate metabolites: dimethylphosphate (DMP, CASRN 813-79-5), dimethylthiophosphate (DMTP, CASRN 1112-38-5), dimethyldithiophosphate (DMDTP, CASRN 765-80-9), diethyl phosphate (DEP, CASRN 598-02-7), diethylthiophosphate (DETP, CASRN 2465-65-8), and diethyldithiophosphate (DEDTP, CASRN 298-06-6).

■ Table 8.7

Organophosphate pesticides and their dialkyl phosphate metabolites (Bravo et al., 2004; CDC, 2005; Wessels et al., 2003)

Organophosphate Pesticides[a]	Dialkyl Phosphate Metabolites					
	DMP	DMTP	DMDTP	DEP	DETP	DEDTP
Acephate	–	–	–	–	–	–
Azinphos-Methyl	■	■	■	–	–	–
Bensulide	–	–	–	–	–	–
Chlorpyrifos	–	–	–	■	■	–
Coumaphos	–	–	–	■	■	–
Diazinon	–	–	–	■	■	–
Dichlorvos (DDVP)	■	–	–	–	–	–
Dimethoate	■	■	■	–	–	–
Fenthion[b]	■	■	–	–	–	–
Malathion	■	■	■	–	–	–
Methamidophos	–	–	–	–	–	–
Naled	■	–	–	–	–	–
Phorate	–	–	–	■	■	■
Phosalone	–	–	–	■	■	■
Phosmet	■	■	■	–	–	–
Propetamphos	–	–	–	–	–	–
Terbufos	–	–	–	■	■	■
Tetrachlorvinphos	■	–	–	–	–	–
Trichlorfon	■	–	–	–	–	–

a Registered for use in Canada at the time of sampling (2007–2009).

b Fenthion is no longer registered for use in Canada (Health Canada, 2009b).

Table 8.7 outlines the organophosphate pesticides (parent compounds) and their corresponding dialkyl phosphate metabolites, which were measured in urine collected from CHMS participants.

Organophosphates are cholinesterase-inhibiting pesticides, which act on the nervous system of insects and mammals by interrupting the transmission of nerve impulses. The result is an overstimulation in the nervous system. Symptoms of exposure may include headache, dizziness, fatigue, irritation of the eyes or nose, nausea, vomiting, salivation, sweating, and changes in heart rate. Much higher doses can have effects such as paralysis, seizures, loss of consciousness, or even death (EPA, 1999; ATSDR, 1997a, 1997b, 2003). These effects are associated with exposure to very high doses and not from typical ingestion of organophosphate pesticides on fruits and vegetables. Organophosphates are suspected of having neurological and neurodevelopmental effects on children (Chenseng et al., 2008; Eskenzai et al., 2007). Although acute toxicity is the primary concern with organophosphates, there is potential for toxic effects resulting from chronic low-dose exposure (Ray & Richards, 2001).

The sale and use of organophosphate pesticides is regulated in Canada by the Pest Management Regulatory Agency (PMRA). The PMRA evaluates the toxicity of pesticides and potential exposure in order to determine whether a pesticide should be approved for a specific use. In 1999, PMRA commenced a re-evaluation of the 27 organophosphate pesticides registered for use at that time in Canada (PMRA, 1999). As a result of this review, nine of these pesticides were subsequently discontinued, and certain other pesticides, such as azinphos-methyl, have been restricted to specific uses, with a plan to phase them out when alternatives can be found (PMRA, 2007). However, the remaining organophosphate pesticides were determined not to pose unacceptable risks to human health or the environment based on their approved uses. As part of the approval process, the PMRA establishes maximum residue limits (MRLs) of pesticides in food. MRLs exist for most registered organophosphate pesticides (Health Canada, 2009d).

The dialkyl phosphate metabolites were measured in morning voids from 89 children aged 3 to 7 in Québec in 2003. The geometric mean and 95th percentile concentrations were 20 and 97 µg/g creatinine for DMP, 18.8 and 210.9 µg/g creatinine for DMTP, 2.8 and 45.9 µg/g creatinine for DMDTP, 4.8 and 29 µg/g creatinine for DEP, 0.7 and 8 µg/g creatinine for DETP, and 0.4 and 0.4 µg/g creatinine for DEDTP (Valcke et al., 2006).

Urinary dialkyl phosphate metabolites were measured in all CHMS participants aged 6–79 years and are presented as µg/L urine and µg/g creatinine (Tables 8.7.1a – 8.7.6b). Finding a measurable amount of organophosphate metabolites in urine is an indicator of exposure to organophosphate pesticides and does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for urinary levels of organophosphate pesticide metabolites in the Canadian population.

8.7.1 Dimethylphosphate (DMP) (CASRN 813-79-5)

Table 8.7.1a

Dimethylphosphate (DMP) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5467	20.27	6.98 6.14 - 7.82	2.96 2.53 - 3.47	<LOD	1.13 <LOD - 1.45	3.06 2.43 - 3.69	7.30 6.63 - 7.97	16.11 14.46 - 17.77	25.00 21.47 - 28.52
6–11	1028	17.51	9.03 7.60 - 10.45	3.88 3.32 - 4.53	<LOD	1.33 <LOD - 1.76	4.36 3.91 - 4.82	11.60 9.42 - 13.78	21.36 18.54 - 24.17	29.86 23.34 - 36.39
12–19	980	15.71	8.83 7.40 - 10.27	3.94 3.26 - 4.76	<LOD	1.69 1.11 - 2.27	4.20 3.41 - 4.99	10.30 8.78 - 11.82	21.49 18.51 - 24.47	28.13 23.94 - 32.32
20–39	1162	23.06	6.55 4.96 - 8.14	2.73 2.26 - 3.29	<LOD	1.01 <LOD - 1.33	2.86 2.25 - 3.47	6.22 5.38 - 7.07	13.55 9.87 - 17.23	23.37 10.89 - 35.85
40–59	1221	26.29	6.45 5.25 - 7.64	2.68 2.16 - 3.32	<LOD	<LOD	2.68 1.79 - 3.56	6.81 5.37 - 8.24	14.91 11.35 - 18.47	24.74 17.93 - 31.54
60–79	1076	17.19	6.73 5.73 - 7.74	3.10 2.69 - 3.58	<LOD	1.36 1.05 - 1.67	3.35 2.75 - 3.95	7.74 6.93 - 8.56	15.27 12.71 - 17.83	21.03 15.63 - 26.43
Males										
Total, age 6–79	2653	19.68	7.07 6.05 - 8.08	3.02 2.56 - 3.56	<LOD	1.21 <LOD - 1.53	3.12 2.41 - 3.84	7.39 6.62 - 8.17	16.48 14.35 - 18.61	25.37 19.93 - 30.82
6–11	524	18.13	8.86 7.11 - 10.62	3.64 2.90 - 4.57	<LOD	1.22 <LOD - 1.68	3.84 2.60 - 5.08	11.73 9.40 - 14.06	20.33 15.67 - 25.00	31.67 22.30 - 41.03
12–19	503	17.69	8.34 6.31 - 10.37	3.56 2.78 - 4.56	<LOD	1.39 <LOD - 2.12	3.71 2.75 - 4.68	10.01 8.21 - 11.80	20.02 16.41 - 23.63	25.60 23.10 - 28.09
20–39	511	22.70	5.89 4.13 - 7.65	2.65 2.21 - 3.18	<LOD	1.01 <LOD - 1.33	2.78 1.94 - 3.61	6.34 5.47 - 7.22	12.47 8.05 - 16.88	17.23 <LOD - 35.95
40–59	577	25.13	6.99 5.07 - 8.92	2.86 2.21 - 3.71	<LOD	1.07 <LOD - 1.56	2.96 1.95 - 3.97	7.09 4.89 - 9.29	15.96 8.82 - 23.09	26.69 15.44 - 37.93
60–79	538	14.31	7.72 6.24 - 9.20	3.51 2.78 - 4.44	<LOD	1.45 <LOD - 2.13	3.48 2.58 - 4.37	8.41 6.78 - 10.04	17.87 15.39 - 20.35	24.89 18.47 - 31.30
Females										
Total, age 6–79	2814	20.82	6.89 5.87 - 7.92	2.91 2.41 - 3.51	<LOD	1.08 <LOD - 1.49	3.00 2.36 - 3.64	7.19 6.12 - 8.26	15.65 13.48 - 17.82	24.99 20.87 - 29.12
6–11	504	16.87	9.20 6.60 - 11.79	4.15 3.21 - 5.35	<LOD	1.65 <LOD - 2.34	4.76 3.62 - 5.90	11.39 7.69 - 15.09	22.13 17.80 - 26.46	29.36 22.54 - 36.18
12–19	477	13.63	9.37 7.79 - 10.96	4.40 3.50 - 5.52	<LOD	2.16 1.27 - 3.05	4.35 3.29 - 5.41	10.36 8.14 - 12.58	22.94 19.14 - 26.74	37.56 22.92 - 52.21
20–39	651	23.35	7.21 4.99 - 9.44	2.81 2.24 - 3.53	<LOD	1.03 <LOD - 1.39	2.90 2.20 - 3.60	6.20 4.91 - 7.50	15.47 10.81 - 20.14	28.98 17.94 - 40.03
40–59	644	27.33	5.90 4.71 - 7.09	2.51 1.93 - 3.25	<LOD	<LOD	2.39 1.42 - 3.36	6.48 4.59 - 8.36	14.86 12.15 - 17.57	21.40 16.54 - 26.25
60–79	538	20.07	5.82 4.68 - 6.97	2.77 2.36 - 3.25	<LOD	1.20 <LOD - 1.55	2.88 2.26 - 3.51	6.74 5.48 - 8.00	12.51 10.15 - 14.87	17.42 11.29 - 23.54

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.7.1b

Dimethylphosphate (DMP) (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5453	20.32	7.06 6.19 - 7.93	3.60 3.11 - 4.17	<LOD	1.69 <LOD - 1.96	3.65 3.11 - 4.20	7.66 6.55 - 8.76	15.29 13.30 - 17.28	24.32 20.24 - 28.40
6–11	1025	17.56	11.83 10.66 - 12.99	5.98 5.26 - 6.81	<LOD	2.62 <LOD - 3.20	6.42 5.08 - 7.76	14.88 13.28 - 16.47	26.90 23.06 - 30.75	40.79 36.12 - 45.47
12–19	978	15.75	6.45 5.65 - 7.26	3.45 2.92 - 4.07	<LOD	1.68 1.41 - 1.95	3.68 2.92 - 4.43	7.86 6.87 - 8.85	13.95 11.24 - 16.66	19.53 14.94 - 24.12
20–39	1158	23.14	6.13 4.66 - 7.60	3.06 2.61 - 3.60	<LOD	1.52 <LOD - 1.85	3.08 2.62 - 3.53	6.15 5.19 - 7.12	13.09 9.52 - 16.65	21.84 13.32 - 30.35
40–59	1216	26.40	6.70 5.63 - 7.78	3.44 2.83 - 4.19	<LOD	<LOD	3.46 2.74 - 4.17	7.21 5.99 - 8.42	14.64 10.91 - 18.36	24.72 16.26 - 33.17
60–79	1076	17.19	7.81 6.65 - 8.98	4.36 3.74 - 5.09	<LOD	2.10 1.45 - 2.74	4.34 3.68 - 5.01	9.44 8.00 - 10.88	16.17 14.63 - 17.70	22.88 18.10 - 27.66
Males										
Total, age 6–79	2644	19.74	6.02 5.20 - 6.84	3.00 2.54 - 3.54	<LOD	1.43 <LOD - 1.78	3.05 2.53 - 3.57	6.52 5.61 - 7.42	12.75 10.89 - 14.61	19.63 15.74 - 23.52
6–11	522	18.20	10.98 9.42 - 12.54	5.51 4.66 - 6.51	<LOD	2.42 <LOD - 2.96	5.65 3.60 - 7.71	13.66 10.42 - 16.90	26.57 20.65 - 32.48	39.94 32.95 - 46.93
12–19	502	17.73	5.79 4.83 - 6.76	3.01 2.47 - 3.66	<LOD	1.50 <LOD - 1.98	3.38 2.50 - 4.26	7.36 6.07 - 8.66	12.36 9.93 - 14.79	16.43 12.90 - 19.95
20–39	509	22.79	4.60 3.40 - 5.80	2.46 2.09 - 2.89	<LOD	1.29 <LOD - 1.66	2.38 1.94 - 2.82	4.79 4.07 - 5.51	9.90 6.36 - 13.45	14.05 <LOD - 22.21
40–59	573	25.31	5.71 4.37 - 7.06	2.83 2.18 - 3.66	<LOD	1.34 <LOD - 1.89	3.07 2.04 - 4.10	5.91 4.68 - 7.13	11.49 7.98 - 15.00	18.80 13.75 - 23.86
60–79	538	14.31	7.23 6.16 - 8.30	3.71 3.08 - 4.46	<LOD	1.65 <LOD - 2.23	3.71 2.75 - 4.67	8.24 6.61 - 9.87	13.70 11.11 - 16.29	20.72 14.61 - 26.84
Females										
Total, age 6–79	2809	20.86	8.09 6.97 - 9.21	4.32 3.69 - 5.05	<LOD	2.01 <LOD - 2.40	4.43 3.63 - 5.23	8.95 7.65 - 10.24	17.97 15.15 - 20.79	27.32 22.93 - 31.71
6–11	503	16.90	12.73 10.87 - 14.58	6.53 5.42 - 7.88	<LOD	3.12 <LOD - 4.08	7.35 5.26 - 9.44	15.18 13.45 - 16.92	26.96 19.97 - 33.95	41.59 33.18 - 49.99
12–19	476	13.66	7.18 6.11 - 8.24	4.00 3.31 - 4.84	<LOD	1.84 1.28 - 2.40	4.03 2.97 - 5.08	8.60 7.26 - 9.94	16.09 12.64 - 19.53	24.32 17.59 - 31.05
20–39	649	23.42	7.66 5.38 - 9.93	3.82 3.13 - 4.66	<LOD	1.70 <LOD - 2.27	4.02 3.20 - 4.84	7.50 6.05 - 8.94	16.67 11.09 - 22.25	25.74 14.76 - 36.72
40–59	643	27.37	7.68 6.43 - 8.93	4.18 3.46 - 5.04	<LOD	<LOD	4.13 3.02 - 5.23	8.45 6.44 - 10.46	17.48 12.79 - 22.17	28.73 18.04 - 39.42
60–79	538	20.07	8.35 6.66 - 10.03	5.07 4.29 - 5.98	<LOD	2.66 <LOD - 3.37	4.85 3.96 - 5.74	10.61 9.09 - 12.14	17.45 15.30 - 19.60	24.62 19.17 - 30.07

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

8.7.2 Dimethylthiophosphate (DMTP) (CASRN 1112-38-5)

■ Table 8.7.2a

Dimethylthiophosphate (DMTP) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5474	30.76	9.13 8.16 - 10.11	2.03 1.69 - 2.44	<LOD	<LOD	2.03 1.44 - 2.63	6.99 5.60 - 8.38	21.95 19.35 - 24.54	40.18 37.24 - 43.12
6–11	1029	27.89	11.97 10.08 - 13.86	2.52 1.97 - 3.23	<LOD	<LOD	2.50 1.49 - 3.50	10.85 7.34 - 14.37	35.98 29.47 - 42.48	55.27 45.66 - 64.88
12–19	980	27.65	10.73 6.42 - 15.03	2.28 1.82 - 2.86	<LOD	<LOD	2.17 1.64 - 2.70	8.10 5.92 - 10.27	26.21 19.75 - 32.68	44.40 29.44 - 59.36
20–39	1163	34.48	8.32 5.09 - 11.54	1.81 1.36 - 2.42	<LOD	<LOD	1.74 1.01 - 2.47	5.67 3.59 - 7.74	17.43 10.41 - 24.45	36.92 19.34 - 54.50
40–59	1223	36.22	8.45 6.69 - 10.20	1.81 1.52 - 2.16	<LOD	<LOD	1.72 1.07 - 2.37	6.26 4.55 - 7.97	19.94 14.68 - 25.21	38.75 27.42 - 50.09
60–79	1079	26.14	9.73 8.56 - 10.89	2.66 2.23 - 3.17	<LOD	<LOD	3.01 2.14 - 3.88	9.04 6.16 - 11.91	26.00 20.98 - 31.03	40.33 34.86 - 45.79
Males										
Total, age 6–79	2659	30.24	8.79 7.31 - 10.27	2.07 1.81 - 2.38	<LOD	<LOD	2.10 1.67 - 2.52	6.57 5.20 - 7.94	22.93 18.99 - 26.86	40.32 36.30 - 44.34
6–11	525	29.33	12.22 9.02 - 15.43	2.50 1.80 - 3.49	<LOD	<LOD	2.37 1.09 - 3.65	12.37 6.35 - 18.38	37.65 28.92 - 46.38	55.52 39.14 - 71.90
12–19	503	28.03	8.95 6.82 - 11.07	2.20 1.77 - 2.73	<LOD	<LOD	2.06 1.44 - 2.67	8.07 5.32 - 10.83	25.14 16.01 - 34.27	38.80 27.97 - 49.63
20–39	512	34.38	7.42 4.26 - 10.59	1.81 1.42 - 2.31	<LOD	<LOD	1.75 1.20 - 2.29	5.13 2.71 - 7.56	19.10 11.47 - 26.73	39.94 15.30 - 64.58
40–59	578	34.60	8.39 4.71 - 12.08	1.92 1.54 - 2.39	<LOD	<LOD	1.99 1.49 - 2.50	6.06 4.09 - 8.02	19.05 9.71 - 28.40	32.87 18.40 - 47.34
60–79	541	24.58	10.51 8.65 - 12.38	2.75 2.17 - 3.48	<LOD	<LOD	2.99 1.85 - 4.13	9.16 4.34 - 13.97	30.88 21.56 - 40.19	42.77 35.04 - 50.49
Females										
Total, age 6–79	2815	31.26	9.47 7.68 - 11.27	1.99 1.54 - 2.57	<LOD	<LOD	1.94 1.07 - 2.82	7.23 5.43 - 9.03	21.11 15.47 - 26.75	39.83 30.78 - 48.87
6–11	504	26.39	11.70 9.66 - 13.75	2.55 1.88 - 3.46	<LOD	<LOD	2.69 1.28 - 4.09	9.36 6.57 - 12.15	31.74 24.09 - 39.39	54.56 42.79 - 66.32
12–19	477	27.25	12.68 3.70 - 21.65	2.38 1.68 - 3.36	<LOD	<LOD	2.35 1.27 - 3.43	8.16 5.18 - 11.15	26.27 11.87 - 40.67	54.75 22.32 - 87.17
20–39	651	34.56	9.21 3.79 - 14.63	1.81 1.26 - 2.61	<LOD	<LOD	1.70 0.68 - 2.73	6.17 3.96 - 8.37	15.59 4.29 - 26.89	34.70 11.03 - 58.38
40–59	645	37.67	8.50 7.06 - 9.94	1.71 1.31 - 2.22	<LOD	<LOD	1.29 <LOD - 2.22	6.57 3.79 - 9.35	21.10 14.85 - 27.36	43.47 20.48 - 66.46
60–79	538	27.70	9.00 6.81 - 11.19	2.58 2.06 - 3.23	<LOD	<LOD	3.04 2.13 - 3.95	8.85 5.72 - 11.99	21.14 14.00 - 28.28	34.25 26.03 - 42.48

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.7.2b

Dimethylthiophosphate (DMTP) (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5460	30.84	10.11 8.85 - 11.38	2.47 2.11 - 2.89	<LOD	<LOD	2.11 1.65 - 2.58	8.04 6.64 - 9.44	22.11 18.45 - 25.77	45.83 38.19 - 53.47
6–11	1026	27.97	17.44 14.23 - 20.66	3.90 3.16 - 4.80	<LOD	<LOD	3.75 2.73 - 4.76	14.44 10.84 - 18.04	45.82 37.06 - 54.58	70.77 52.79 - 88.74
12–19	978	27.71	7.92 5.88 - 9.95	1.99 1.63 - 2.44	<LOD	<LOD	2.01 1.64 - 2.38	6.26 4.63 - 7.89	19.19 13.80 - 24.59	30.05 23.31 - 36.80
20–39	1159	34.60	8.46 5.46 - 11.45	2.03 1.58 - 2.62	<LOD	<LOD	1.79 1.30 - 2.27	5.81 3.93 - 7.69	17.09 9.08 - 25.09	35.25 18.32 - 52.17
40–59	1218	36.37	9.63 8.09 - 11.16	2.32 1.98 - 2.72	<LOD	<LOD	1.87 1.35 - 2.39	7.50 5.66 - 9.34	19.26 16.09 - 22.43	45.87 37.36 - 54.38
60–79	1079	26.14	12.38 10.77 - 13.99	3.73 3.16 - 4.40	<LOD	<LOD	3.87 2.80 - 4.94	13.20 10.61 - 15.80	29.89 21.99 - 37.78	53.87 40.27 - 67.47
Males										
Total, age 6–79	2650	30.34	8.05 6.79 - 9.32	2.05 1.80 - 2.35	<LOD	<LOD	1.86 1.51 - 2.20	6.32 4.98 - 7.67	18.70 15.19 - 22.21	34.01 24.53 - 43.49
6–11	523	29.45	15.52 10.57 - 20.46	3.79 2.80 - 5.12	<LOD	<LOD	3.40 1.77 - 5.02	15.52 9.76 - 21.28	45.94 33.22 - 58.67	64.13 38.09 - 90.17
12–19	502	28.09	6.62 4.83 - 8.40	1.85 1.50 - 2.30	<LOD	<LOD	1.84 1.31 - 2.36	5.47 3.55 - 7.40	19.14 10.57 - 27.71	28.50 20.77 - 36.23
20–39	510	34.51	6.42 4.15 - 8.68	1.68 1.37 - 2.06	<LOD	<LOD	1.55 1.22 - 1.88	4.76 3.02 - 6.50	12.79 7.11 - 18.47	27.07 7.36 - 46.79
40–59	574	34.84	7.07 5.02 - 9.11	1.89 1.51 - 2.37	<LOD	<LOD	1.75 1.26 - 2.25	5.36 2.47 - 8.25	16.36 12.50 - 20.22	23.06 13.24 - 32.87
60–79	541	24.58	10.78 9.23 - 12.32	2.90 2.40 - 3.49	<LOD	<LOD	3.07 2.10 - 4.04	10.83 6.00 - 15.66	23.21 15.63 - 30.79	41.00 26.01 - 56.00
Females										
Total, age 6–79	2810	31.32	12.16 10.30 - 14.01	2.96 2.39 - 3.65	<LOD	<LOD	2.55 1.81 - 3.30	9.58 7.60 - 11.55	27.67 21.33 - 34.01	51.62 42.89 - 60.34
6–11	503	26.44	19.49 14.03 - 24.96	4.01 3.14 - 5.12	<LOD	<LOD	4.17 2.77 - 5.58	13.48 9.57 - 17.40	44.77 32.95 - 56.59	79.68 52.76 - 106.60
12–19	476	27.31	9.34 5.14 - 13.55	2.16 1.66 - 2.81	<LOD	<LOD	2.08 1.69 - 2.47	7.25 5.34 - 9.16	21.18 13.44 - 28.93	34.85 4.33 - 65.37
20–39	649	34.67	10.49 5.70 - 15.28	2.46 1.77 - 3.42	<LOD	<LOD	2.07 1.38 - 2.76	7.05 4.00 - 10.11	21.78 8.66 - 34.91	36.68 10.45 - 62.92
40–59	644	37.73	12.15 9.04 - 15.26	2.84 2.32 - 3.49	<LOD	<LOD	2.20 <LOD - 3.09	9.20 7.16 - 11.24	27.31 15.45 - 39.17	49.62 18.31 - 80.93
60–79	538	27.70	13.86 11.44 - 16.28	4.70 3.80 - 5.82	<LOD	<LOD	4.82 2.67 - 6.96	13.92 9.58 - 18.26	34.59 21.38 - 47.80	54.72 43.38 - 66.06

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

8.7.3 Dimethyldithiophosphate (DMDTP) (CASRN 765-80-9)

Table 8.7.3a

Dimethyldithiophosphate (DMDTP) – Arithmetic and geometric means, and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5475	61.95	—	—	<LOD	<LOD	<LOD	0.64 0.42 - 0.85	2.66 1.84 - 3.49	5.99 5.10 - 6.87
6–11	1029	57.92	—	—	<LOD	<LOD	<LOD	0.89 0.61 - 1.17	3.61 2.58 - 4.64	7.21 4.85 - 9.56
12–19	980	62.04	—	—	<LOD	<LOD	<LOD	0.56 0.30 - 0.82	2.34 1.45 - 3.24	7.09 4.91 - 9.26
20–39	1163	66.98	—	—	<LOD	<LOD	<LOD	0.52 <LOD - 0.75	1.91 1.12 - 2.70	4.57 2.42 - 6.72
40–59	1223	66.56	—	—	<LOD	<LOD	<LOD	0.56 0.33 - 0.79	2.43 0.84 - 4.02	5.87 4.24 - 7.50
60–79	1080	55.09	—	—	<LOD	<LOD	<LOD	1.02 0.66 - 1.38	3.95 2.45 - 5.45	7.43 5.01 - 9.86
Males										
Total, age 6–79	2659	62.24	—	—	<LOD	<LOD	<LOD	0.59 0.39 - 0.79	2.44 1.43 - 3.45	5.60 4.44 - 6.75
6–11	525	59.62	—	—	<LOD	<LOD	<LOD	0.82 0.37 - 1.28	4.26 2.23 - 6.29	8.57 3.76 - 13.37
12–19	503	62.03	—	—	<LOD	<LOD	<LOD	0.53 <LOD - 0.79	2.03 0.82 - 3.24	4.55 <LOD - 8.93
20–39	512	67.97	—	—	<LOD	<LOD	<LOD	0.52 <LOD - 0.75	1.99 1.22 - 2.75	4.54 1.94 - 7.14
40–59	578	66.26	—	—	<LOD	<LOD	<LOD	0.60 0.36 - 0.84	2.07 0.57 - 3.57	5.67 4.34 - 7.00
60–79	541	55.27	—	—	<LOD	<LOD	<LOD	1.00 0.70 - 1.30	3.94 2.55 - 5.34	7.49 2.36 - 12.62
Females										
Total, age 6–79	2816	61.68	—	—	<LOD	<LOD	<LOD	0.68 0.41 - 0.96	2.94 1.76 - 4.12	6.63 4.74 - 8.51
6–11	504	56.15	—	—	<LOD	<LOD	<LOD	0.96 0.56 - 1.37	2.99 2.33 - 3.64	5.69 3.13 - 8.25
12–19	477	62.05	—	—	<LOD	<LOD	<LOD	0.67 <LOD - 1.15	2.90 <LOD - 6.53	7.91 2.86 - 12.96
20–39	651	66.21	—	—	<LOD	<LOD	<LOD	0.57 0.33 - 0.80	1.84 <LOD - 3.47	5.46 0.44 - 10.48
40–59	645	66.82	—	—	<LOD	<LOD	<LOD	0.51 <LOD - 0.87	3.55 1.65 - 5.46	6.81 <LOD - 13.79
60–79	539	54.92	—	—	<LOD	<LOD	<LOD	1.08 0.44 - 1.71	3.74 1.09 - 6.38	7.33 4.03 - 10.62

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.7.3b

Dimethyldithiophosphate (DMDTP) (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5461	62.11	—	—	<LOD	<LOD	<LOD	0.87 0.70 - 1.05	3.30 2.56 - 4.04	7.34 5.55 - 9.13
6–11	1026	58.09	—	—	<LOD	<LOD	<LOD	1.36 1.00 - 1.72	5.53 3.58 - 7.48	11.22 8.46 - 13.99
12–19	978	62.17	—	—	<LOD	<LOD	<LOD	0.58 0.36 - 0.80	2.17 1.33 - 3.01	5.32 3.13 - 7.50
20–39	1159	67.21	—	—	<LOD	<LOD	<LOD	0.71 <LOD - 0.89	2.05 1.04 - 3.06	4.77 2.64 - 6.91
40–59	1218	66.83	—	—	<LOD	<LOD	<LOD	0.84 0.66 - 1.01	3.20 2.21 - 4.18	8.72 6.06 - 11.37
60–79	1080	55.09	—	—	<LOD	<LOD	<LOD	1.42 1.01 - 1.82	4.61 2.99 - 6.24	9.32 2.99 - 15.64
Males										
Total, age 6–79	2650	62.45	—	—	<LOD	<LOD	<LOD	0.68 0.51 - 0.85	2.27 1.46 - 3.09	5.62 2.91 - 8.34
6–11	523	59.85	—	—	<LOD	<LOD	<LOD	1.31 0.54 - 2.08	6.12 2.53 - 9.72	12.09 7.41 - 16.77
12–19	502	62.15	—	—	<LOD	<LOD	<LOD	0.49 <LOD - 0.63	1.55 0.51 - 2.60	4.08 <LOD - 8.59
20–39	510	68.24	—	—	<LOD	<LOD	<LOD	0.54 <LOD - 0.70	1.46 0.82 - 2.09	3.02 0.32 - 5.73
40–59	574	66.72	—	—	<LOD	<LOD	<LOD	0.59 0.32 - 0.87	2.36 0.96 - 3.76	5.14 1.47 - 8.82
60–79	541	55.27	—	—	<LOD	<LOD	<LOD	0.96 0.62 - 1.30	3.49 2.17 - 4.81	8.04 2.50 - 13.57
Females										
Total, age 6–79	2811	61.79	—	—	<LOD	<LOD	<LOD	1.10 0.83 - 1.38	4.07 2.86 - 5.28	8.67 6.12 - 11.22
6–11	503	56.26	—	—	<LOD	<LOD	<LOD	1.37 1.01 - 1.74	4.23 2.58 - 5.87	9.96 7.35 - 12.56
12–19	476	62.18	—	—	<LOD	<LOD	<LOD	0.77 <LOD - 1.09	2.70 <LOD - 4.59	6.26 <LOD - 13.68
20–39	649	66.41	—	—	<LOD	<LOD	<LOD	0.74 0.42 - 1.06	3.14 <LOD - 5.25	5.87 <LOD - 11.55
40–59	644	66.93	—	—	<LOD	<LOD	<LOD	1.00 <LOD - 1.29	4.53 1.57 - 7.49	10.84 <LOD - 14.60
60–79	539	54.92	—	—	<LOD	<LOD	<LOD	1.98 0.98 - 2.99	5.83 3.75 - 7.90	10.58 2.32 - 18.85

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

8.7.4 Diethyl Phosphate (DEP) (CASRN 598-02-7)

Table 8.7.4a

Diethyl phosphate (DEP) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5475	20.40	4.16 3.77 - 4.55	2.30 1.99 - 2.65	<LOD	1.18 <LOD - 1.50	2.33 2.03 - 2.64	4.74 4.47 - 5.02	8.80 7.89 - 9.70	12.98 11.28 - 14.68
6–11	1029	17.88	6.15 4.43 - 7.88	2.87 2.26 - 3.65	<LOD	1.30 <LOD - 1.81	3.00 2.37 - 3.63	6.44 5.53 - 7.35	11.91 9.62 - 14.21	17.18 13.93 - 20.44
12–19	980	17.35	5.70 4.46 - 6.94	2.97 2.43 - 3.63	<LOD	1.46 <LOD - 2.03	3.11 2.46 - 3.76	6.24 5.24 - 7.23	12.42 9.51 - 15.33	18.38 14.14 - 22.62
20–39	1163	22.96	3.82 2.91 - 4.73	2.15 1.76 - 2.62	<LOD	1.12 <LOD - 1.54	2.21 1.84 - 2.57	4.17 3.67 - 4.68	7.81 5.94 - 9.69	12.19 9.27 - 15.12
40–59	1223	25.35	3.60 3.09 - 4.12	2.09 1.79 - 2.43	<LOD	1.01 <LOD - 1.44	2.14 1.81 - 2.48	4.51 3.86 - 5.17	7.61 5.96 - 9.26	11.34 8.83 - 13.85
60–79	1080	17.22	4.01 3.56 - 4.46	2.41 2.18 - 2.67	<LOD	1.34 1.07 - 1.60	2.38 2.06 - 2.69	4.87 4.34 - 5.41	8.85 7.75 - 9.94	12.02 10.21 - 13.83
Males										
Total, age 6–79	2659	19.03	4.37 3.93 - 4.81	2.38 2.08 - 2.73	<LOD	1.23 <LOD - 1.58	2.42 2.08 - 2.76	4.86 4.56 - 5.17	9.34 8.21 - 10.47	13.46 11.03 - 15.89
6–11	525	18.67	7.11 4.36 - 9.87	2.89 2.19 - 3.81	<LOD	1.32 <LOD - 2.00	2.94 1.99 - 3.89	6.56 5.39 - 7.73	11.39 9.36 - 13.42	18.38 12.74 - 24.02
12–19	503	16.30	5.78 3.97 - 7.59	2.91 2.38 - 3.57	<LOD	1.47 <LOD - 1.97	2.89 2.09 - 3.69	6.16 4.91 - 7.41	13.16 9.58 - 16.73	17.52 13.75 - 21.29
20–39	512	22.66	3.59 2.87 - 4.31	2.09 1.70 - 2.58	<LOD	<LOD <LOD - 1.72	2.21 1.76 - 2.66	4.04 3.30 - 4.79	8.24 6.03 - 10.46	11.64 8.27 - 15.01
40–59	578	21.45	3.93 3.24 - 4.62	2.25 1.91 - 2.66	<LOD	1.23 <LOD - 1.55	2.30 1.80 - 2.80	4.71 3.89 - 5.54	7.85 5.44 - 10.27	11.95 7.84 - 16.05
60–79	541	15.90	4.48 3.61 - 5.35	2.68 2.27 - 3.17	<LOD	1.46 1.10 - 1.82	2.63 1.93 - 3.33	5.30 4.27 - 6.33	9.53 8.12 - 10.94	13.34 10.01 - 16.67
Females										
Total, age 6–79	2816	21.70	3.95 3.40 - 4.50	2.22 1.89 - 2.60	<LOD	1.14 <LOD - 1.45	2.27 1.98 - 2.56	4.61 4.20 - 5.02	8.22 7.00 - 9.44	12.40 10.25 - 14.56
6–11	504	17.06	5.13 4.12 - 6.15	2.86 2.22 - 3.69	<LOD	1.30 <LOD - 1.82	3.09 2.40 - 3.78	6.34 5.24 - 7.43	12.57 9.63 - 15.51	16.86 13.29 - 20.44
12–19	477	18.45	5.61 4.61 - 6.61	3.03 2.42 - 3.78	<LOD	1.45 <LOD - 2.25	3.21 2.51 - 3.92	6.43 5.11 - 7.74	11.57 7.86 - 15.27	21.73 15.15 - 28.32
20–39	651	23.20	4.05 2.70 - 5.40	2.20 1.77 - 2.74	<LOD	1.18 <LOD - 1.56	2.21 1.84 - 2.57	4.23 3.71 - 4.74	7.22 4.99 - 9.44	12.85 8.28 - 17.43
40–59	645	28.84	3.28 2.75 - 3.82	1.94 1.62 - 2.32	<LOD	<LOD	2.03 1.64 - 2.42	4.19 3.32 - 5.07	7.50 5.70 - 9.30	10.55 8.04 - 13.05
60–79	539	18.55	3.58 3.08 - 4.08	2.19 2.00 - 2.40	<LOD	1.26 <LOD - 1.53	2.15 1.92 - 2.37	4.14 3.31 - 4.96	7.92 6.41 - 9.43	11.03 8.79 - 13.27

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.7.4b

Diethyl phosphate (DEP) (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5461	20.45	4.54 4.24 - 4.84	2.79 2.50 - 3.11	<LOD	1.54 <LOD - 1.79	2.86 2.53 - 3.18	5.28 5.00 - 5.57	9.08 8.52 - 9.64	12.66 12.01 - 13.31
6–11	1026	17.93	8.07 6.45 - 9.68	4.43 3.73 - 5.27	<LOD	2.38 <LOD - 2.88	4.26 3.60 - 4.91	8.47 7.19 - 9.76	17.05 13.22 - 20.89	25.10 20.14 - 30.06
12–19	978	17.38	4.24 3.65 - 4.84	2.59 2.19 - 3.06	<LOD	1.40 <LOD - 1.71	2.60 2.17 - 3.03	5.18 4.68 - 5.69	8.71 7.88 - 9.54	12.13 10.25 - 14.00
20–39	1159	23.04	3.80 3.23 - 4.37	2.41 2.05 - 2.82	<LOD	1.35 <LOD - 1.67	2.36 2.02 - 2.69	4.52 3.98 - 5.07	7.39 6.61 - 8.16	9.99 8.00 - 11.99
40–59	1218	25.45	4.25 3.75 - 4.74	2.68 2.40 - 2.99	<LOD	1.47 <LOD - 1.66	2.75 2.39 - 3.12	5.16 4.75 - 5.57	8.99 7.08 - 10.91	11.83 10.40 - 13.26
60–79	1080	17.22	5.14 4.46 - 5.83	3.38 3.06 - 3.75	<LOD	2.02 1.65 - 2.38	3.56 3.17 - 3.94	6.24 5.56 - 6.92	10.27 8.76 - 11.77	13.66 10.81 - 16.51
Males										
Total, age 6–79	2650	19.09	3.99 3.69 - 4.29	2.36 2.11 - 2.63	<LOD	1.28 <LOD - 1.52	2.48 2.24 - 2.71	4.53 4.20 - 4.86	8.10 7.34 - 8.85	11.19 10.25 - 12.14
6–11	523	18.74	8.56 6.23 - 10.90	4.36 3.60 - 5.28	<LOD	2.38 <LOD - 2.80	4.33 3.35 - 5.31	8.26 7.16 - 9.37	13.67 10.64 - 16.71	25.11 17.14 - 33.08
12–19	502	16.33	4.14 3.41 - 4.87	2.46 2.10 - 2.87	<LOD	1.28 <LOD - 1.55	2.55 2.19 - 2.91	5.11 4.59 - 5.63	8.37 7.04 - 9.71	11.09 8.39 - 13.78
20–39	510	22.75	2.94 2.56 - 3.31	1.94 1.66 - 2.27	<LOD	<LOD <LOD - 1.44	1.89 1.56 - 2.22	3.55 2.96 - 4.15	5.98 5.05 - 6.91	7.72 6.62 - 8.82
40–59	574	21.60	3.71 3.21 - 4.22	2.22 1.94 - 2.55	<LOD	1.18 <LOD - 1.45	2.37 2.02 - 2.73	4.20 3.50 - 4.89	8.55 5.85 - 11.25	11.27 9.92 - 12.61
60–79	541	15.90	4.37 3.60 - 5.15	2.83 2.47 - 3.24	<LOD	1.64 1.25 - 2.04	3.08 2.67 - 3.50	5.30 4.58 - 6.03	8.87 7.41 - 10.34	10.98 8.59 - 13.36
Females										
Total, age 6–79	2811	21.74	5.08 4.66 - 5.50	3.29 2.92 - 3.71	<LOD	1.87 <LOD - 2.18	3.40 2.93 - 3.86	5.96 5.48 - 6.44	10.01 8.91 - 11.11	14.51 12.46 - 16.56
6–11	503	17.10	7.54 6.27 - 8.81	4.51 3.73 - 5.44	<LOD	2.45 <LOD - 3.10	4.21 3.60 - 4.82	8.93 6.58 - 11.29	17.79 13.13 - 22.46	24.90 18.90 - 30.90
12–19	476	18.49	4.36 3.81 - 4.91	2.75 2.26 - 3.34	<LOD	1.57 <LOD - 1.97	2.65 1.96 - 3.34	5.20 4.33 - 6.06	9.11 7.97 - 10.24	13.03 11.22 - 14.83
20–39	649	23.27	4.66 3.72 - 5.61	2.99 2.51 - 3.56	<LOD	1.78 <LOD - 2.33	2.90 2.41 - 3.40	5.43 4.87 - 5.99	8.62 7.26 - 9.98	13.19 9.84 - 16.54
40–59	644	28.88	4.78 4.19 - 5.37	3.22 2.87 - 3.62	<LOD	<LOD	3.41 2.79 - 4.04	5.66 5.01 - 6.31	9.17 7.34 - 11.00	12.37 9.88 - 14.86
60–79	539	18.55	5.85 4.96 - 6.74	3.99 3.52 - 4.52	<LOD	2.22 <LOD - 2.71	4.09 3.43 - 4.76	7.07 5.94 - 8.21	11.22 8.71 - 13.74	17.89 9.87 - 25.92

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

8.7.5 Diethylthiophosphate (DETP) (CASRN 2465-65-8)

Table 8.7.5a

Diethylthiophosphate (DETP) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5474	59.77	—	—	<LOD	<LOD	<LOD	0.99 0.80 - 1.17	2.20 1.93 - 2.47	4.01 3.21 - 4.81
6–11	1029	54.71	—	—	<LOD	<LOD	<LOD	1.17 0.91 - 1.42	2.93 2.15 - 3.71	4.84 3.92 - 5.76
12–19	979	54.55	—	—	<LOD	<LOD	<LOD	1.18 0.87 - 1.49	2.62 1.83 - 3.40	4.08 3.08 - 5.07
20–39	1163	64.14	—	—	<LOD	<LOD	<LOD	0.88 0.69 - 1.08	1.90 1.52 - 2.28	2.90 1.92 - 3.88
40–59	1223	65.74	—	—	<LOD	<LOD	<LOD	0.98 0.71 - 1.26	2.17 1.56 - 2.79	4.66 2.79 - 6.52
60–79	1080	57.87	—	—	<LOD	<LOD	<LOD	1.10 0.91 - 1.30	2.59 2.23 - 2.95	4.15 3.59 - 4.72
Males										
Total, age 6–79	2658	58.50	—	—	<LOD	<LOD	<LOD	0.98 0.80 - 1.17	2.16 1.79 - 2.53	4.08 2.86 - 5.30
6–11	525	53.90	—	—	<LOD	<LOD	<LOD	1.18 0.85 - 1.52	2.92 1.95 - 3.90	5.39 2.54 - 8.24
12–19	502	54.38	—	—	<LOD	<LOD	<LOD	1.10 0.83 - 1.36	2.58 1.84 - 3.32	4.38 2.24 - 6.52
20–39	512	64.06	—	—	<LOD	<LOD	<LOD	0.87 0.64 - 1.10	1.86 1.37 - 2.36	2.82 1.46 - 4.18
40–59	578	65.92	—	—	<LOD	<LOD	<LOD	0.96 0.69 - 1.22	2.13 1.41 - 2.86	4.57 2.73 - 6.41
60–79	541	53.60	—	—	<LOD	<LOD	<LOD	1.28 1.02 - 1.54	2.97 2.25 - 3.68	4.17 1.95 - 6.38
Females										
Total, age 6–79	2816	60.97	—	—	<LOD	<LOD	<LOD	0.99 0.79 - 1.20	2.29 1.96 - 2.61	3.90 3.01 - 4.79
6–11	504	55.56	—	—	<LOD	<LOD	<LOD	1.07 0.69 - 1.46	2.98 1.79 - 4.18	4.28 3.24 - 5.32
12–19	477	54.72	—	—	<LOD	<LOD	<LOD	1.23 0.81 - 1.65	2.82 1.54 - 4.10	4.03 3.31 - 4.75
20–39	651	64.21	—	—	<LOD	<LOD	<LOD	0.93 0.68 - 1.18	2.03 1.41 - 2.64	3.56 2.13 - 5.00
40–59	645	65.58	—	—	<LOD	<LOD	<LOD	1.02 0.68 - 1.35	2.36 1.47 - 3.25	5.24 2.53 - 7.95
60–79	539	62.15	—	—	<LOD	<LOD	<LOD	0.95 0.74 - 1.16	2.00 1.37 - 2.62	3.58 2.42 - 4.73

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.7.5b

Diethylthiophosphate (DETP) (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5460	59.93	—	—	<LOD	<LOD	<LOD	1.29 1.15 - 1.43	2.70 2.38 - 3.01	4.42 3.65 - 5.19
6–11	1026	54.87	—	—	<LOD	<LOD	<LOD	1.87 1.65 - 2.10	4.31 3.17 - 5.45	6.50 4.45 - 8.56
12–19	977	54.66	—	—	<LOD	<LOD	<LOD	0.99 0.82 - 1.16	1.92 1.65 - 2.19	3.18 2.11 - 4.24
20–39	1159	64.37	—	—	<LOD	<LOD	<LOD	1.08 0.89 - 1.26	2.12 1.70 - 2.54	3.56 2.65 - 4.47
40–59	1218	66.01	—	—	<LOD	<LOD	<LOD	1.35 1.17 - 1.53	3.08 2.47 - 3.68	5.45 3.52 - 7.39
60–79	1080	57.87	—	—	<LOD	<LOD	<LOD	1.50 1.24 - 1.76	2.89 2.38 - 3.40	4.12 2.80 - 5.44
Males										
Total, age 6–79	2649	58.70	—	—	<LOD	<LOD	<LOD	1.02 0.91 - 1.13	2.14 1.81 - 2.48	3.62 3.12 - 4.13
6–11	523	54.11	—	—	<LOD	<LOD	<LOD	1.87 1.45 - 2.29	3.74 2.69 - 4.78	6.69 3.85 - 9.53
12–19	501	54.49	—	—	<LOD	<LOD	<LOD	0.93 0.77 - 1.09	1.73 1.36 - 2.09	3.03 0.99 - 5.06
20–39	510	64.31	—	—	<LOD	<LOD	<LOD	0.86 0.76 - 0.95	1.68 1.35 - 2.00	2.42 2.01 - 2.83
40–59	574	66.38	—	—	<LOD	<LOD	<LOD	0.97 0.80 - 1.13	2.37 1.90 - 2.83	3.78 2.71 - 4.86
60–79	541	53.60	—	—	<LOD	<LOD	<LOD	1.21 1.00 - 1.43	2.82 2.17 - 3.47	3.85 1.33 - 6.37
Females										
Total, age 6–79	2811	61.08	—	—	<LOD	<LOD	<LOD	1.53 1.33 - 1.72	3.23 2.71 - 3.76	4.91 3.99 - 5.83
6–11	503	55.67	—	—	<LOD	<LOD	<LOD	1.89 1.38 - 2.39	4.59 2.99 - 6.18	6.11 3.46 - 8.76
12–19	476	54.83	—	—	<LOD	<LOD	<LOD	1.08 0.84 - 1.33	2.00 1.60 - 2.39	3.40 2.51 - 4.30
20–39	649	64.41	—	—	<LOD	<LOD	<LOD	1.37 1.06 - 1.68	2.86 1.81 - 3.91	4.27 3.09 - 5.44
40–59	644	65.68	—	—	<LOD	<LOD	<LOD	1.66 1.44 - 1.87	3.84 2.99 - 4.69	7.13 4.13 - 10.14
60–79	539	62.15	—	—	<LOD	<LOD	<LOD	1.83 1.52 - 2.14	2.99 2.31 - 3.68	4.54 3.27 - 5.82

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

8.7.6 Diethyldithiophosphate (DEDTP) (CASRN 298-06-6)

Table 8.7.6a

Diethyldithiophosphate (DEDTP) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5475	96.84	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
6–11	1029	96.21	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
12–19	980	96.12	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	1163	97.08	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	1223	97.30	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	1080	97.31	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 6–79	2659	96.35	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
6–11	525	96.19	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
12–19	503	95.83	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	512	97.07	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	578	96.89	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	541	95.75	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 6–79	2816	97.30	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
6–11	504	96.23	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
12–19	477	96.44	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	651	97.08	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	645	97.67	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	539	98.89	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.7.6b

Diethyldithiophosphate (DEDTP) (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95% CI	G.M. 95% CI	10th 95% CI	25th 95% CI	50th 95% CI	75th 95% CI	90th 95% CI	95th 95% CI
Total, age 6–79	5461	97.09	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
6–11	1026	96.49	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
12–19	978	96.32	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	1159	97.41	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	1218	97.70	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	1080	97.31	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Males										
Total, age 6–79	2650	96.68	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
6–11	523	96.56	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
12–19	502	96.02	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	510	97.45	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	574	97.56	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	541	95.75	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Females										
Total, age 6–79	2811	97.47	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
6–11	503	96.42	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
12–19	476	96.64	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	649	97.38	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	644	97.83	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	539	98.89	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.8 PYRETHROID INSECTICIDES (METABOLITES)

Pyrethrins are naturally occurring compounds found in certain chrysanthemum flowers. Pyrethrins have been used for their insecticidal properties since the early 1800s in Asia to control ticks and various insects such as fleas and mosquitoes. Pyrethroids are synthetic versions of pyrethrins, which have been structurally altered to improve their efficacy as pesticides by increasing their stability in the environment and their toxicity (ATSDR, 2003; EPA, 2009). There are several commercial pyrethroid pesticides, including allethrin, cyfluthrin, *lambda*-cyhalothrin, cypermethrin, deltamethrin, fluvalinate-*tau*, permethrin, d-phenothrin, resmethrin, and tetramethrin.

Pyrethroid pesticides are used in Canada for insect control on agricultural crops; in orchards, nurseries, and greenhouses; as a general residential insecticide; for controlling adult mosquitoes around buildings; in cattle ear tags; and for flea and tick control on pets (Health Canada, 2009a). In malaria-endemic zones, pyrethroids are used to impregnate mosquito nets and clothing for the prevention of malaria (Health Canada, 2004). The use of pyrethrins and pyrethroids has increased during the past decade with the declining use of organophosphate pesticides, which are more acutely toxic to birds and mammals than pyrethroids (EPA, 2009).

The metabolites of cyfluthrin, *lambda*-cyhalothrin, cypermethrin, deltamethrin, fluvalinate-*tau*, permethrin, and d-phenothrin are commonly measured in biomonitoring studies as biomarkers of exposure to pyrethroids. Permethrin is the most widely used pyrethroid pesticide in Canada, with over 250 registered pesticide products (CCME, 2006; Health Canada, 2009a). It is used for a variety of agricultural, livestock, forestry, and residential insect control applications. In addition to the pesticide uses, permethrin is used in medications for the treatment of scabies (Health Canada, 2009b). Cyfluthrin is used as an agricultural and indoor surface insecticide for control of crawling and flying insect pests (Health Canada, 2009a). Cypermethrin and *lambda*-cyhalothrin have agricultural and livestock uses. Deltamethrin is used in several agricultural applications, on turf, and in greenhouses; it is also used to treat sleeping areas and clothing in malaria-affected countries (Health Canada, 2009a, 2004). D-phenothrin is used primarily in residential settings while fluvalinate-*tau* is used to control mites in bee colonies (Health Canada, 2009a).

Pyrethroid exposure to the general population occurs primarily through the use of products that contain pyrethroids, such as household insecticides and pet sprays, and through the ingestion of food and drinking water contaminated with pyrethroid residues (EPA, 2006; ATSDR, 2003). Pyrethroids enter the environment primarily due to their use as pesticides; however, they break down rapidly and, as a result, only trace amounts of the chemicals are typically found in air, water, soil, and food. Pyrethroids bind strongly to soil particles, thus they usually do not leach into the groundwater, but rather remain in the soil (ATSDR, 2003). Pyrethroids degrade to carboxylic and phenoxybenzoic metabolites in the environment and these metabolites have been measured in dust collected from homes and daycare centres (Starr et al., 2008).

Pyrethroid pesticides are rapidly metabolized and eliminated from the body through hydrolysis, oxidation and conjugation. Following oral ingestion, inhalation, or dermal intake, pyrethroids are metabolized into carboxylic and phenoxybenzoic acids and excreted with urine. Pyrethroids and metabolites can be measured in blood and urine and are reflective of recent exposure to the parent compound or the metabolite in the environment (i.e., during the previous few days) (ATSDR, 2003; Kuhn et al., 1999; IARC, 2000; Starr et al., 2008). Several urinary metabolites are specific to one pyrethroid while others are common to several pyrethroids.

Table 8.8

Pyrethroid pesticides and their metabolites
(Barr & Needham, 2002; CDC, 2009; Fortin et al., 2008; Starr et al., 2008)

Pyrethroid (CASRN)	Metabolite (CASRN)
Cyfluthrin (68359-37-5) Flumethrin[a] (69770-45-2)	4-Fluoro-3-Phenoxybenzoic Acid, 4-F-3-PBA (77279-89-1)
Deltamethrin (52918-63-5)	*cis*-3-(2,2-Dibromovinyl)-2,2-Dimethylcyclopropane-1-Carboxylic Acid, *cis*-DBCA (63597-73-9)
cis-Permethrin (61949-76-6) Cyfluthrin (61949-76-6) *cis*-Cypermethrin (52316-07-8)	*cis*- 3-(2,2-Dichlorovinyl)-2,2-Dimethylcyclopropane Carboxylic Acid, *cis*-DCCA (55701-03-6)
trans-Permethrin (61949-77-7) Cyfluthrin (61949-76-6) *trans*-Cypermethrin (65732-07-2)	*trans*- 3-(2,2-Dichlorovinyl)-2,2-Dimethylcyclopropane Carboxylic Acid, *trans*-DCCA (55701-03-6)
Cypermethrin (52315-07-8) Deltamethrin (52918-63-5) Permethrin (52645-53-1) *lambda*-Cyhalothrin (91465-08-6) d-Phenothrin (26046-85-5) Fluvalinate-*tau* (102851-06-9) Esfenvalerate[a] (66230-04-4) Fenpropathrin[a] (39515-41-8) Flucythrinate[a] (70124-77-5) Tralomethrin (66841-25-6)	3-Phenoxybenzoic Acid, 3-PBA (3739-38-6)

[a] Not registered for use in Canada at the time of sampling (March 2007–March 2009).

The following table outlines the pyrethroid metabolites and their corresponding parent compounds that have been measured as part of this survey.

Pyrethroids, much like the naturally occurring pyrethrins, primarily affect the nervous system of mammals and insects. They act on the axons in the peripheral and central nervous systems by prolonging the opening time of small conductance sodium channels, leading to membrane depolarizations and excess excitability. This causes paralysis in target insect pests, eventually resulting in death.

Mammals are able to quickly metabolize pyrethroids into their inactive forms and eliminate them from the body. As such, toxic effects from the ingestion of pyrethroids are rare, and are normally associated with accidental ingestion of pyrethroid pesticides as opposed to typical exposure. Effects can include dizziness, nausea, headaches, tremor, salivation, choreoathetosis, and seizures; very high exposures may result in unconsciousness (ATSDR, 2003; CDC, 2005). Studies indicate that long-term exposures to low levels of pyrethroids do not cause neurological effects in mammals, primarily due to the rapid metabolism and elimination of these compounds from the body (ATSDR, 2003). The United States Environmental Protection Agency has classified permethrin as "likely to be carcinogenic in humans" by the oral route of exposure (EPA, 2006). Allergic reactions in humans are common following exposure to pyrethroids and may result in symptoms similar to allergic reactions to pollen (i.e., sneezing, nasal discharge, and sinus congestion) (Health Canada, 2009c).

The sale and use of pyrethroid pesticides is regulated in Canada by the Pest Management Regulatory Agency (PMRA). The PMRA evaluates the toxicity and potential exposure in order to determine whether a pesticide should be approved for a specific use. As part of this approval process, the PMRA specifies maximum residue limits (MRLs) of pesticides in food. MRLs exist for several pyrethroid pesticides in food, including cyfluthrin, cypermethrin, and permethrin (Health Canada, 2009d). Several pyrethroids are currently under re-evaluation by the PMRA (Health Canada, 2009e).

Pyrethroid metabolites were measured in 89 children (6–12 years) and 81 adults (18–64 years) in Québec in 2005. Metabolites were identified in urine collected for 12 hours from children, or in urine collected for two consecutive 12-hour periods in adults. In children, the median and 95th percentile concentrations were <0.005 and 0.02 µg/L for 4-F-3-PBA, <0.006 and 0.09 µg/L for *cis*-DBCA, 0.10 and 0.76 µg/L for *cis*-DCCA, 0.24 and 4.10 µg/L for *trans*-DCCA, 0.20 and 1.54 µg/L for 3-PBA. In adults, the median and 95th percentile concentrations were <0.005 and 0.03 µg/L for 4-F-3-PBA, <0.006 and 0.14 µg/L for *cis*-DBCA, 0.10 and 1.15 µg/L for *cis*-DCCA, 0.25 and 3.48 µg/L for *trans*-DCCA, and 0.17 and 4.23 µg/L for 3-PBA (Fortin et al., 2008).

Urinary pyrethroid metabolites were measured in all CHMS participants aged 6–79 years and are presented as µg/L urine and µg/g creatinine (Tables 8.8.1a – 8.8.5b). Finding a measurable amount of pyrethroid pesticide metabolites in urine is an indicator of exposure to pyrethroid pesticides and does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for urinary levels of pyrethroid pesticide metabolites in the Canadian population.

8.8.1 4-Fluoro-3-Phenoxybenzoic Acid (4-F-3-PBA)

■ Table 8.8.1a

4-Fluoro-3-Phenoxybenzoic Acid (4-F-3-PBA) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5224	56.45	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.03 0.02 - 0.05	0.08 0.05 - 0.10
6–11	998	57.52	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.02 0.02 - 0.03	0.04 0.01 - 0.07
12–19	947	49.10	—	—	<LOD	<LOD	<LOD <LOD - 0.01	0.01 0.01 - 0.02	0.04 0.03 - 0.05	0.06 0.02 - 0.10
20–39	1100	54.82	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.04 0.01 - 0.06	0.09 0.03 - 0.15
40–59	1161	59.09	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.04 0.03 - 0.05	0.08 0.05 - 0.11
60–79	1018	61.00	—	—	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.03 0.01 - 0.05	0.07 0.02 - 0.12
Males										
Total, age 6–79	2529	54.49	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.04 0.02 - 0.06	0.09 0.05 - 0.14
6–11	515	56.31	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.03 0.01 - 0.04	0.05 0.02 - 0.08
12–19	485	47.22	—	—	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.01 - 0.02	0.04 0.02 - 0.05	0.06 0.03 - 0.09
20–39	484	52.89	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.05 <LOD - 0.10	0.11 0.03 - 0.20
40–59	541	57.30	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.04 0.02 - 0.07	0.11 0.05 - 0.17
60–79	504	58.13	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.04 0.02 - 0.05	0.07 0.03 - 0.11
Females										
Total, age 6–79	2695	58.29	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.03 0.02 - 0.04	0.06 0.05 - 0.07
6–11	483	58.80	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.01	0.02 0.01 - 0.03	0.03 <LOD - 0.06
12–19	462	51.08	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.03 0.01 - 0.05	0.06 <LOD - 0.18
20–39	616	56.33	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.03 0.02 - 0.04	0.07 0.03 - 0.10
40–59	620	60.65	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.03 0.02 - 0.04	0.06 0.03 - 0.08
60–79	514	63.81	—	—	<LOD	<LOD	<LOD	0.01 <LOD - 0.01	0.03 0.01 - 0.05	0.06 <LOD - 0.17

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.8.1b

4-fluoro-3-phenoxybenzoic acid (4-F-3-PBA) (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5210	56.60	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.04 0.03 - 0.05	0.07 0.04 - 0.11
6–11	995	57.69	—	—	<LOD	<LOD	<LOD	0.02 0.02 - 0.02	0.04 0.03 - 0.05	0.07 0.05 - 0.10
12–19	945	49.21	—	—	<LOD	<LOD	<LOD <LOD - 0.01	0.01 0.01 - 0.02	0.03 0.02 - 0.03	0.05 0.02 - 0.07
20–39	1096	55.02	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.04 0.03 - 0.06	0.07 <LOD - 0.14
40–59	1156	59.34	—	—	<LOD	<LOD	<LOD	0.02 0.02 - 0.02	0.04 0.03 - 0.05	0.08 0.04 - 0.12
60–79	1018	61.00	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.02	0.04 0.02 - 0.06	0.09 0.03 - 0.16
Males										
Total, age 6–79	2520	54.68	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.04 0.02 - 0.05	0.07 <LOD - 0.13
6–11	513	56.53	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.04 0.03 - 0.05	0.07 0.04 - 0.11
12–19	484	47.31	—	—	<LOD	<LOD	<LOD <LOD - 0.01	0.01 0.01 - 0.02	0.03 0.02 - 0.04	0.04 0.03 - 0.05
20–39	482	53.11	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.04 <LOD - 0.07	0.07 <LOD - 0.18
40–59	537	57.73	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.04 0.01 - 0.06	0.11 <LOD - 0.21
60–79	504	58.13	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.03 0.01 - 0.04	0.06 0.03 - 0.08
Females										
Total, age 6–79	2690	58.40	—	—	<LOD	<LOD	<LOD	0.02 0.02 - 0.02	0.04 0.03 - 0.05	0.07 0.04 - 0.10
6–11	482	58.92	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.04 0.03 - 0.05	0.06 <LOD - 0.10
12–19	461	51.19	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.03 0.01 - 0.05	0.06 <LOD - 0.27
20–39	614	56.51	—	—	<LOD	<LOD	<LOD	0.02 0.02 - 0.02	0.04 0.03 - 0.06	0.07 0.04 - 0.11
40–59	619	60.74	—	—	<LOD	<LOD	<LOD	0.02 0.02 - 0.03	0.05 0.03 - 0.06	0.07 0.05 - 0.09
60–79	514	63.81	—	—	<LOD	<LOD	<LOD	0.02 <LOD - 0.03	0.05 <LOD - 0.09	0.11 <LOD - 0.25

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

8.8.2 *cis*-3-(2,2-Dibromovinyl)-2,2-Dimethylcyclopropane Carboxylic Acid (*cis*-DBCA)

Table 8.8.2a

cis-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropane-1-carboxylic acid (*cis*-DBCA) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5022	50.36	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.04 0.04 - 0.05	0.07 0.06 - 0.09
6–11	974	48.67	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.04 0.03 - 0.06	0.10 0.06 - 0.14
12–19	927	43.26	—	—	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.01 - 0.03	0.05 0.04 - 0.06	0.09 0.07 - 0.10
20–39	1055	52.13	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.04 0.03 - 0.05	0.08 0.05 - 0.12
40–59	1109	54.19	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.05 0.04 - 0.05	0.07 0.06 - 0.08
60–79	957	52.56	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.04 0.03 - 0.05	0.07 0.05 - 0.09
Males										
Total, age 6–79	2433	49.65	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.04 0.04 - 0.05	0.07 0.06 - 0.09
6–11	501	50.70	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.04 0.02 - 0.06	0.07 0.05 - 0.10
12–19	476	42.44	—	—	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.02 - 0.03	0.05 0.04 - 0.06	0.08 0.07 - 0.10
20–39	463	50.97	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.03 0.02 - 0.04	0.06 0.02 - 0.09
40–59	513	52.05	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.03	0.05 0.03 - 0.06	0.07 0.05 - 0.09
60–79	480	51.88	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.04 0.03 - 0.06	0.07 0.05 - 0.10
Females										
Total, age 6–79	2589	51.02	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.04 0.03 - 0.05	0.07 0.05 - 0.09
6–11	473	46.51	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.05 0.02 - 0.07	0.11 0.06 - 0.16
12–19	451	44.12	—	—	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.01 - 0.03	0.04 0.02 - 0.06	0.09 0.05 - 0.12
20–39	592	53.04	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.05 0.03 - 0.07	0.09 0.06 - 0.13
40–59	596	56.04	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.04 0.02 - 0.05	0.06 0.05 - 0.08
60–79	477	53.25	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.04 0.03 - 0.05	0.07 0.05 - 0.09

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.8.2b

cis-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropane-1-carboxylic acid (*cis*-DBCA) (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5008	50.50	—	—	<LOD	<LOD	<LOD	0.02 0.02 - 0.02	0.05 0.04 - 0.06	0.09 0.07 - 0.11
6–11	971	48.82	—	—	<LOD	<LOD	<LOD	0.02 0.02 - 0.03	0.07 0.05 - 0.08	0.14 0.08 - 0.20
12–19	925	43.35	—	—	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.01 - 0.02	0.04 0.03 - 0.04	0.07 0.05 - 0.09
20–39	1051	52.33	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.04 0.03 - 0.05	0.08 0.04 - 0.12
40–59	1104	54.44	—	—	<LOD	<LOD	<LOD	0.02 0.02 - 0.02	0.05 0.04 - 0.06	0.09 0.06 - 0.12
60–79	957	52.56	—	—	<LOD	<LOD	<LOD	0.02 0.02 - 0.03	0.06 0.05 - 0.07	0.08 0.06 - 0.10
Males										
Total, age 6–79	2424	49.83	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.04 0.03 - 0.05	0.07 0.05 - 0.09
6–11	499	50.90	—	—	<LOD	<LOD	<LOD	0.02 0.02 - 0.03	0.06 0.04 - 0.08	0.11 0.03 - 0.18
12–19	475	42.53	—	—	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.01 - 0.02	0.04 0.03 - 0.04	0.09 0.06 - 0.12
20–39	461	51.19	—	—	<LOD	<LOD	<LOD	0.01 0.01 - 0.02	0.03 0.02 - 0.04	0.06 0.02 - 0.09
40–59	509	52.46	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.04 0.02 - 0.06	0.07 0.03 - 0.10
60–79	480	51.88	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.02	0.05 0.04 - 0.07	0.07 0.05 - 0.08
Females										
Total, age 6–79	2584	51.12	—	—	<LOD	<LOD	<LOD	0.02 0.02 - 0.03	0.05 0.04 - 0.06	0.10 0.07 - 0.12
6–11	472	46.61	—	—	<LOD	<LOD	<LOD	0.03 0.02 - 0.03	0.07 0.03 - 0.10	0.15 0.05 - 0.24
12–19	450	44.22	—	—	<LOD	<LOD	0.01 <LOD - 0.01	0.02 0.01 - 0.02	0.04 0.02 - 0.05	0.06 0.04 - 0.07
20–39	590	53.22	—	—	<LOD	<LOD	<LOD	0.02 0.01 - 0.03	0.05 0.03 - 0.08	0.10 0.06 - 0.15
40–59	595	56.13	—	—	<LOD	<LOD	<LOD	0.02 0.02 - 0.03	0.05 0.04 - 0.07	0.09 0.07 - 0.12
60–79	477	53.25	—	—	<LOD	<LOD	<LOD	0.03 0.02 - 0.04	0.06 0.05 - 0.07	0.09 0.07 - 0.12

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

8.8.3 *cis*-3-(2,2-Dichlorovinyl)-2,2-Dimethylcyclopropane Carboxylic Acid (*cis*-DCCA)

Table 8.8.3a

cis-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*cis*-DCCA) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5431	1.57	0.37 0.22 - 0.51	0.08 0.07 - 0.10	0.02 0.01 - 0.02	0.03 0.03 - 0.04	0.07 0.06 - 0.09	0.18 0.14 - 0.21	0.50 0.38 - 0.62	0.94 0.69 - 1.19
6–11	1026	2.73	0.13 0.09 - 0.17	0.05 0.04 - 0.07	0.01 0.01 - 0.02	0.02 0.02 - 0.03	0.05 0.04 - 0.06	0.10 0.08 - 0.11	0.22 0.15 - 0.28	0.38 0.19 - 0.57
12–19	970	0.82	0.29 0.21 - 0.37	0.09 0.07 - 0.12	0.02 0.01 - 0.03	0.04 0.03 - 0.05	0.08 0.05 - 0.10	0.19 0.13 - 0.24	0.52 0.20 - 0.85	1.06 0.37 - 1.74
20–39	1151	1.13	0.56 0.14 - 0.98	0.09 0.07 - 0.11	0.02 0.02 - 0.02	0.04 0.03 - 0.05	0.08 0.06 - 0.09	0.16 0.12 - 0.19	0.45 0.31 - 0.60	0.75 0.34 - 1.16
40–59	1208	2.15	0.29 0.19 - 0.38	0.09 0.07 - 0.11	0.02 0.01 - 0.02	0.03 0.03 - 0.04	0.08 0.05 - 0.10	0.21 0.16 - 0.27	0.60 0.42 - 0.78	1.24 0.92 - 1.56
60–79	1076	0.93	0.33 0.15 - 0.52	0.08 0.07 - 0.10	0.02 0.01 - 0.02	0.04 0.03 - 0.04	0.07 0.05 - 0.08	0.16 0.10 - 0.23	0.42 0.25 - 0.59	0.75 0.47 - 1.03
Males										
Total, age 6–79	2636	1.37	0.44 0.20 - 0.68	0.09 0.07 - 0.11	0.02 0.02 - 0.03	0.04 0.03 - 0.04	0.07 0.06 - 0.09	0.18 0.13 - 0.22	0.53 0.37 - 0.69	1.09 0.77 - 1.41
6–11	524	2.48	0.14 0.07 - 0.21	0.05 0.04 - 0.07	0.01 <LOD - 0.02	0.03 0.02 - 0.04	0.05 0.03 - 0.06	0.09 0.08 - 0.11	0.22 0.14 - 0.31	0.36 0.03 - 0.68
12–19	498	0.20	0.20 0.10 - 0.30	0.08 0.06 - 0.11	0.02 0.02 - 0.02	0.04 0.03 - 0.05	0.07 0.05 - 0.09	0.14 0.08 - 0.20	0.43 0.02 - 0.84	1.02 0.37 - 1.67
20–39	506	1.78	0.68 <LOD - 1.41	0.09 0.07 - 0.11	0.02 0.01 - 0.03	0.04 0.03 - 0.04	0.08 0.05 - 0.10	0.17 0.11 - 0.23	0.46 0.29 - 0.62	1.05 0.13 - 1.97
40–59	569	1.76	0.36 0.19 - 0.54	0.10 0.08 - 0.14	0.02 0.01 - 0.03	0.04 0.03 - 0.05	0.08 0.05 - 0.11	0.24 0.14 - 0.33	0.91 0.58 - 1.24	1.31 0.45 - 2.17
60–79	539	0.56	0.43 0.10 - 0.76	0.09 0.07 - 0.12	0.03 0.02 - 0.03	0.04 0.03 - 0.05	0.08 0.05 - 0.10	0.18 0.11 - 0.24	0.40 0.24 - 0.56	0.71 0.50 - 0.93
Females										
Total, age 6–79	2795	1.75	0.30 0.15 - 0.45	0.08 0.07 - 0.10	0.02 0.01 - 0.02	0.03 0.03 - 0.04	0.07 0.05 - 0.09	0.17 0.13 - 0.21	0.46 0.34 - 0.57	0.79 0.62 - 0.96
6–11	502	2.99	0.13 0.09 - 0.16	0.06 0.04 - 0.07	0.01 0.01 - 0.02	0.02 0.02 - 0.03	0.05 0.04 - 0.07	0.12 0.09 - 0.14	0.21 0.14 - 0.28	0.42 0.23 - 0.60
12–19	472	1.48	0.38 0.25 - 0.50	0.10 0.07 - 0.15	0.02 <LOD - 0.03	0.04 0.02 - 0.06	0.09 0.05 - 0.12	0.22 0.13 - 0.31	0.74 0.49 - 0.99	1.78 0.20 - 3.35
20–39	645	0.62	0.43 0.02 - 0.85	0.08 0.07 - 0.10	0.02 0.01 - 0.02	0.04 0.03 - 0.05	0.08 0.06 - 0.10	0.15 0.11 - 0.18	0.37 0.24 - 0.51	0.68 0.46 - 0.90
40–59	639	2.50	0.21 0.17 - 0.26	0.08 0.06 - 0.10	0.01 <LOD - 0.02	0.03 0.02 - 0.04	0.07 0.05 - 0.10	0.19 0.14 - 0.24	0.51 0.36 - 0.65	0.79 0.54 - 1.04
60–79	537	1.30	0.25 0.13 - 0.36	0.08 0.06 - 0.10	0.02 0.01 - 0.02	0.03 0.03 - 0.04	0.06 0.04 - 0.08	0.15 0.07 - 0.23	0.43 0.23 - 0.64	0.86 0.44 - 1.28

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.8.3b

cis-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*cis*-DCCA) (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5417	1.57	0.33 0.24 - 0.41	0.10 0.09 - 0.12	0.03 0.02 - 0.03	0.05 0.04 - 0.06	0.09 0.07 - 0.10	0.18 0.14 - 0.23	0.50 0.35 - 0.64	1.13 0.87 - 1.38
6–11	1023	2.74	0.20 0.14 - 0.25	0.08 0.07 - 0.10	0.03 0.02 - 0.03	0.04 0.04 - 0.05	0.07 0.06 - 0.08	0.14 0.10 - 0.17	0.30 0.19 - 0.42	0.58 0.19 - 0.97
12–19	968	0.83	0.22 0.16 - 0.29	0.08 0.06 - 0.10	0.02 0.02 - 0.03	0.03 0.03 - 0.04	0.06 0.04 - 0.08	0.15 0.11 - 0.19	0.43 0.23 - 0.64	0.99 0.54 - 1.44
20–39	1147	1.13	0.36 0.18 - 0.53	0.10 0.08 - 0.12	0.03 0.02 - 0.03	0.04 0.04 - 0.05	0.08 0.07 - 0.10	0.17 0.13 - 0.20	0.38 0.23 - 0.53	0.82 0.38 - 1.27
40–59	1203	2.16	0.35 0.22 - 0.47	0.12 0.10 - 0.14	0.03 0.02 - 0.04	0.05 0.04 - 0.06	0.10 0.08 - 0.12	0.23 0.15 - 0.32	0.65 0.42 - 0.87	1.26 0.99 - 1.53
60–79	1076	0.93	0.36 0.22 - 0.50	0.12 0.09 - 0.14	0.03 0.03 - 0.04	0.05 0.04 - 0.06	0.09 0.07 - 0.12	0.20 0.12 - 0.28	0.49 0.19 - 0.79	1.17 0.59 - 1.75
Males										
Total, age 6–79	2627	1.37	0.32 0.19 - 0.44	0.09 0.07 - 0.11	0.02 0.02 - 0.03	0.04 0.03 - 0.04	0.07 0.06 - 0.08	0.16 0.11 - 0.20	0.44 0.29 - 0.59	1.02 0.66 - 1.38
6–11	522	2.49	0.20 0.11 - 0.30	0.08 0.07 - 0.09	0.03 <LOD - 0.03	0.04 0.04 - 0.05	0.07 0.06 - 0.07	0.12 0.09 - 0.16	0.29 0.10 - 0.49	0.63 0.05 - 1.21
12–19	497	0.20	0.16 0.08 - 0.25	0.07 0.05 - 0.09	0.02 0.02 - 0.03	0.03 0.02 - 0.04	0.05 0.04 - 0.07	0.13 0.08 - 0.18	0.32 <LOD - 0.67	0.71 0.24 - 1.17
20–39	504	1.79	0.34 <LOD - 0.58	0.08 0.07 - 0.10	0.02 0.02 - 0.03	0.04 0.03 - 0.04	0.07 0.05 - 0.08	0.14 0.09 - 0.19	0.36 0.11 - 0.60	0.97 0.13 - 1.82
40–59	565	1.77	0.37 0.13 - 0.61	0.10 0.08 - 0.13	0.02 0.02 - 0.03	0.04 0.03 - 0.05	0.08 0.06 - 0.10	0.21 0.12 - 0.30	0.65 0.35 - 0.94	1.35 0.62 - 2.09
60–79	539	0.56	0.33 0.17 - 0.50	0.10 0.08 - 0.11	0.03 0.02 - 0.04	0.05 0.04 - 0.05	0.07 0.05 - 0.10	0.17 0.12 - 0.22	0.41 0.31 - 0.50	0.67 0.28 - 1.05
Females										
Total, age 6–79	2790	1.76	0.34 0.25 - 0.42	0.12 0.10 - 0.14	0.03 0.03 - 0.04	0.05 0.05 - 0.06	0.10 0.08 - 0.12	0.20 0.13 - 0.27	0.55 0.41 - 0.69	1.19 0.99 - 1.39
6–11	501	2.99	0.19 0.13 - 0.24	0.09 0.07 - 0.11	0.03 0.02 - 0.04	0.04 0.04 - 0.05	0.08 0.06 - 0.10	0.16 0.12 - 0.20	0.30 0.18 - 0.43	0.54 0.35 - 0.73
12–19	471	1.49	0.29 0.20 - 0.38	0.09 0.07 - 0.12	0.02 <LOD - 0.03	0.04 0.02 - 0.05	0.07 0.05 - 0.09	0.17 0.12 - 0.21	0.45 0.29 - 0.61	1.64 0.49 - 2.79
20–39	643	0.62	0.38 0.17 - 0.58	0.11 0.09 - 0.14	0.03 0.02 - 0.04	0.06 0.05 - 0.07	0.10 0.08 - 0.12	0.18 0.14 - 0.23	0.43 0.28 - 0.58	0.80 0.40 - 1.20
40–59	638	2.51	0.33 0.28 - 0.37	0.13 0.11 - 0.16	0.04 <LOD - 0.05	0.06 0.05 - 0.07	0.11 0.09 - 0.13	0.25 0.14 - 0.36	0.64 0.37 - 0.91	1.20 1.01 - 1.38
60–79	537	1.30	0.38 0.21 - 0.55	0.14 0.11 - 0.18	0.04 0.03 - 0.05	0.06 0.05 - 0.07	0.11 0.08 - 0.15	0.25 0.12 - 0.38	0.75 0.22 - 1.28	1.54 0.86 - 2.23

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

8.8.4 *trans*-3-(2,2-Dichlorovinyl)-2,2-Dimethylcyclopropane Carboxylic Acid (*trans*-DCCA)

■ Table 8.8.4a

trans-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*trans*-DCCA) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5457	0.40	1.13 0.55 - 1.72	0.20 0.17 - 0.24	0.04 0.03 - 0.05	0.08 0.07 - 0.09	0.17 0.15 - 0.20	0.43 0.33 - 0.53	1.26 0.95 - 1.56	2.53 1.95 - 3.11
6–11	1027	0.29	0.49 0.37 - 0.61	0.17 0.15 - 0.21	0.04 0.03 - 0.06	0.08 0.06 - 0.09	0.15 0.13 - 0.18	0.34 0.27 - 0.41	0.83 0.55 - 1.11	1.47 1.09 - 1.84
12–19	978	0.10	0.88 0.51 - 1.26	0.24 0.18 - 0.32	0.05 0.03 - 0.07	0.10 0.07 - 0.13	0.21 0.17 - 0.24	0.48 0.27 - 0.70	1.47 0.53 - 2.40	3.78 1.97 - 5.59
20–39	1158	0.60	1.87 0.06 - 3.69	0.20 0.16 - 0.24	0.04 0.03 - 0.05	0.08 0.06 - 0.09	0.18 0.14 - 0.21	0.40 0.30 - 0.49	1.09 0.73 - 1.45	2.00 1.21 - 2.79
40–59	1216	0.58	0.82 0.47 - 1.16	0.21 0.17 - 0.26	0.04 0.03 - 0.04	0.08 0.06 - 0.09	0.18 0.13 - 0.23	0.51 0.33 - 0.69	1.62 0.86 - 2.37	3.23 1.90 - 4.56
60–79	1078	0.37	0.85 0.36 - 1.34	0.18 0.15 - 0.22	0.04 0.03 - 0.05	0.07 0.06 - 0.08	0.15 0.12 - 0.18	0.36 0.22 - 0.50	1.10 0.80 - 1.40	1.91 1.18 - 2.64
Males										
Total, age 6–79	2650	0.30	1.47 0.31 - 2.64	0.22 0.18 - 0.26	0.05 0.04 - 0.06	0.09 0.07 - 0.10	0.18 0.16 - 0.20	0.45 0.31 - 0.58	1.33 0.70 - 1.96	2.86 1.46 - 4.27
6–11	524	0.19	0.51 0.28 - 0.75	0.17 0.13 - 0.22	0.04 0.02 - 0.06	0.08 0.05 - 0.11	0.14 0.11 - 0.18	0.30 0.24 - 0.36	0.81 0.44 - 1.18	1.50 0.83 - 2.16
12–19	501	0.00	0.69 0.08 - 1.31	0.22 0.17 - 0.30	0.05 0.03 - 0.06	0.10 0.07 - 0.13	0.19 0.16 - 0.22	0.43 0.24 - 0.62	1.31 0.29 - 2.34	2.41 0.76 - 4.06
20–39	510	0.78	2.67 <LOD - 6.32	0.21 0.16 - 0.26	0.04 0.03 - 0.06	0.08 0.06 - 0.10	0.18 0.14 - 0.22	0.41 0.25 - 0.58	1.02 0.52 - 1.52	2.21 <LOD - 4.46
40–59	576	0.35	1.05 0.37 - 1.74	0.25 0.19 - 0.33	0.04 0.03 - 0.06	0.09 0.07 - 0.10	0.20 0.15 - 0.25	0.60 0.36 - 0.85	2.45 1.25 - 3.64	4.20 0.98 - 7.42
60–79	539	0.19	1.06 0.20 - 1.93	0.20 0.16 - 0.25	0.05 0.04 - 0.06	0.08 0.07 - 0.10	0.17 0.14 - 0.21	0.39 0.25 - 0.52	1.10 0.80 - 1.39	1.71 1.09 - 2.33
Females										
Total, age 6–79	2807	0.50	0.79 0.45 - 1.13	0.19 0.16 - 0.22	0.04 0.03 - 0.04	0.07 0.06 - 0.08	0.17 0.13 - 0.20	0.42 0.33 - 0.51	1.22 0.99 - 1.44	2.18 1.57 - 2.79
6–11	503	0.40	0.47 0.33 - 0.60	0.18 0.15 - 0.22	0.04 0.03 - 0.06	0.07 0.06 - 0.09	0.17 0.12 - 0.21	0.39 0.28 - 0.49	0.84 0.46 - 1.23	1.46 1.01 - 1.91
12–19	477	0.21	1.09 0.65 - 1.53	0.26 0.19 - 0.38	0.05 0.02 - 0.07	0.09 0.05 - 0.14	0.22 0.17 - 0.27	0.66 0.36 - 0.96	1.75 0.23 - 3.27	4.48 0.44 - 8.52
20–39	648	0.46	1.07 0.17 - 1.97	0.19 0.16 - 0.23	0.04 0.03 - 0.05	0.07 0.06 - 0.09	0.18 0.13 - 0.22	0.38 0.29 - 0.46	1.16 0.75 - 1.56	1.76 1.11 - 2.41
40–59	640	0.78	0.58 0.44 - 0.72	0.18 0.15 - 0.23	0.03 0.03 - 0.04	0.06 0.04 - 0.08	0.16 0.10 - 0.22	0.45 0.27 - 0.63	1.20 0.92 - 1.48	2.23 1.43 - 3.02
60–79	539	0.56	0.65 0.31 - 0.99	0.16 0.13 - 0.20	0.03 0.03 - 0.04	0.07 0.05 - 0.08	0.13 0.10 - 0.16	0.30 0.11 - 0.50	1.11 0.60 - 1.62	2.02 0.90 - 3.14

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.8.4b

trans-3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*trans*-DCCA) (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5443	0.40	0.93 0.66 - 1.20	0.25 0.21 - 0.29	0.06 0.06 - 0.07	0.10 0.09 - 0.12	0.19 0.17 - 0.22	0.46 0.36 - 0.56	1.36 1.01 - 1.70	3.05 2.36 - 3.74
6–11	1024	0.29	0.71 0.51 - 0.90	0.27 0.24 - 0.31	0.09 0.08 - 0.10	0.13 0.12 - 0.14	0.22 0.19 - 0.25	0.46 0.38 - 0.55	1.06 0.68 - 1.44	2.48 1.35 - 3.60
12–19	976	0.10	0.66 0.41 - 0.91	0.21 0.17 - 0.27	0.06 0.05 - 0.07	0.09 0.07 - 0.11	0.16 0.11 - 0.20	0.43 0.26 - 0.61	1.27 0.65 - 1.89	2.37 1.26 - 3.48
20–39	1154	0.61	1.02 0.46 - 1.59	0.22 0.18 - 0.26	0.06 0.05 - 0.07	0.10 0.08 - 0.11	0.18 0.14 - 0.21	0.41 0.32 - 0.50	1.07 0.76 - 1.38	2.30 1.35 - 3.26
40–59	1211	0.58	0.99 0.55 - 1.43	0.27 0.23 - 0.33	0.06 0.06 - 0.07	0.11 0.10 - 0.12	0.21 0.18 - 0.24	0.50 0.30 - 0.70	1.75 1.19 - 2.30	3.67 2.92 - 4.41
60–79	1078	0.37	0.91 0.54 - 1.29	0.25 0.21 - 0.30	0.07 0.06 - 0.07	0.10 0.09 - 0.12	0.21 0.17 - 0.25	0.48 0.29 - 0.66	1.30 0.72 - 1.89	2.98 1.74 - 4.22
Males										
Total, age 6–79	2641	0.30	0.94 0.49 - 1.40	0.22 0.18 - 0.26	0.05 0.05 - 0.06	0.09 0.08 - 0.10	0.17 0.14 - 0.20	0.40 0.29 - 0.51	1.20 0.73 - 1.68	2.66 1.68 - 3.65
6–11	522	0.19	0.76 0.42 - 1.10	0.26 0.22 - 0.30	0.08 0.07 - 0.09	0.12 0.11 - 0.14	0.21 0.18 - 0.24	0.40 0.31 - 0.50	1.06 0.21 - 1.91	2.57 0.80 - 4.35
12–19	500	0.00	0.52 0.11 - 0.93	0.19 0.14 - 0.25	0.05 0.05 - 0.06	0.08 0.06 - 0.10	0.15 0.11 - 0.19	0.39 0.20 - 0.59	0.96 <LOD - 1.97	1.82 0.99 - 2.65
20–39	508	0.79	1.08 <LOD - 2.05	0.19 0.16 - 0.24	0.05 0.04 - 0.07	0.09 0.07 - 0.10	0.15 0.12 - 0.18	0.32 0.22 - 0.43	0.92 0.46 - 1.37	2.53 <LOD - 4.30
40–59	572	0.35	1.08 0.18 - 1.98	0.25 0.19 - 0.31	0.06 0.04 - 0.07	0.09 0.08 - 0.11	0.19 0.16 - 0.23	0.50 0.30 - 0.70	1.75 1.02 - 2.48	3.91 1.96 - 5.86
60–79	539	0.19	0.80 0.41 - 1.19	0.21 0.18 - 0.25	0.06 0.05 - 0.07	0.09 0.07 - 0.10	0.17 0.14 - 0.20	0.38 0.24 - 0.51	1.00 0.71 - 1.28	1.70 1.02 - 2.38
Females										
Total, age 6–79	2802	0.50	0.92 0.71 - 1.13	0.28 0.24 - 0.32	0.07 0.06 - 0.08	0.12 0.10 - 0.13	0.22 0.18 - 0.27	0.51 0.38 - 0.65	1.41 1.14 - 1.69	3.37 2.80 - 3.94
6–11	502	0.40	0.65 0.47 - 0.83	0.29 0.24 - 0.34	0.09 0.07 - 0.10	0.13 0.11 - 0.15	0.23 0.17 - 0.28	0.51 0.36 - 0.67	1.04 0.62 - 1.46	2.02 0.63 - 3.42
12–19	476	0.21	0.81 0.50 - 1.12	0.24 0.19 - 0.30	0.06 0.05 - 0.07	0.10 0.07 - 0.13	0.17 0.12 - 0.23	0.49 0.29 - 0.69	1.29 0.72 - 1.86	3.79 0.56 - 7.01
20–39	646	0.46	0.97 0.50 - 1.44	0.25 0.21 - 0.31	0.06 0.05 - 0.08	0.11 0.10 - 0.13	0.21 0.15 - 0.27	0.47 0.36 - 0.58	1.21 0.88 - 1.53	2.28 1.10 - 3.46
40–59	639	0.78	0.91 0.77 - 1.05	0.30 0.26 - 0.36	0.08 0.06 - 0.09	0.14 0.11 - 0.16	0.23 0.17 - 0.28	0.54 0.28 - 0.80	1.73 0.84 - 2.62	3.60 3.01 - 4.20
60–79	539	0.56	1.02 0.48 - 1.56	0.30 0.23 - 0.38	0.07 0.06 - 0.09	0.12 0.10 - 0.13	0.25 0.18 - 0.32	0.57 0.34 - 0.80	1.74 0.40 - 3.08	3.59 1.69 - 5.49

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

8.8.5 3-Phenoxybenzoic Acid (3-PBA)

Table 8.8.5a

3-Phenoxybenzoic acid (3-PBA) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5450	0.61	1.09 0.58 - 1.60	0.25 0.21 - 0.31	0.05 0.04 - 0.06	0.10 0.08 - 0.12	0.23 0.18 - 0.28	0.56 0.43 - 0.69	1.51 1.14 - 1.88	2.96 2.11 - 3.81
6–11	1025	0.68	0.55 0.40 - 0.71	0.21 0.16 - 0.27	0.05 0.03 - 0.06	0.10 0.07 - 0.13	0.19 0.14 - 0.25	0.42 0.33 - 0.51	1.14 0.78 - 1.51	1.78 0.60 - 2.97
12–19	977	0.20	0.87 0.59 - 1.15	0.28 0.21 - 0.38	0.06 0.03 - 0.09	0.11 0.09 - 0.14	0.26 0.18 - 0.33	0.62 0.44 - 0.81	2.08 1.06 - 3.10	3.26 2.01 - 4.50
20–39	1159	0.35	1.66 0.13 - 3.19	0.25 0.20 - 0.32	0.05 0.04 - 0.07	0.10 0.07 - 0.13	0.22 0.17 - 0.27	0.51 0.39 - 0.63	1.45 1.03 - 1.87	2.54 1.60 - 3.49
40–59	1216	1.07	0.84 0.48 - 1.21	0.27 0.21 - 0.34	0.05 0.03 - 0.06	0.10 0.08 - 0.12	0.25 0.19 - 0.32	0.65 0.48 - 0.82	1.74 0.97 - 2.51	3.54 2.08 - 5.01
60–79	1073	0.65	0.92 0.36 - 1.48	0.24 0.20 - 0.29	0.05 0.04 - 0.06	0.10 0.07 - 0.12	0.21 0.17 - 0.25	0.52 0.34 - 0.70	1.31 0.89 - 1.72	2.22 1.58 - 2.87
Males										
Total, age 6–79	2646	0.42	1.38 0.40 - 2.37	0.27 0.22 - 0.33	0.05 0.04 - 0.07	0.11 0.09 - 0.13	0.23 0.18 - 0.28	0.57 0.43 - 0.70	1.52 1.13 - 1.91	3.29 2.18 - 4.40
6–11	524	0.38	0.56 0.32 - 0.80	0.20 0.14 - 0.29	0.05 0.02 - 0.07	0.10 0.06 - 0.14	0.18 0.12 - 0.23	0.38 0.27 - 0.50	1.00 0.55 - 1.46	1.72 <LOD - 3.86
12–19	501	0.00	0.67 0.31 - 1.03	0.26 0.20 - 0.35	0.06 0.04 - 0.09	0.11 0.10 - 0.13	0.23 0.16 - 0.30	0.56 0.32 - 0.80	1.54 0.43 - 2.64	2.51 1.41 - 3.60
20–39	511	0.39	2.36 <LOD - 5.42	0.26 0.20 - 0.34	0.05 0.03 - 0.07	0.11 0.07 - 0.15	0.21 0.16 - 0.27	0.52 0.38 - 0.67	1.40 0.87 - 1.94	2.33 0.67 - 3.99
40–59	575	0.70	1.00 0.36 - 1.64	0.30 0.23 - 0.40	0.05 0.04 - 0.07	0.11 0.09 - 0.13	0.28 0.20 - 0.35	0.72 0.41 - 1.04	2.06 <LOD - 4.29	4.12 1.60 - 6.64
60–79	535	0.56	1.20 0.13 - 2.27	0.26 0.21 - 0.32	0.06 0.04 - 0.07	0.11 0.07 - 0.14	0.23 0.17 - 0.29	0.62 0.42 - 0.82	1.41 0.92 - 1.89	2.26 1.63 - 2.88
Females										
Total, age 6–79	2804	0.78	0.80 0.52 - 1.08	0.24 0.19 - 0.30	0.04 0.03 - 0.06	0.09 0.07 - 0.12	0.22 0.17 - 0.27	0.55 0.41 - 0.69	1.45 0.98 - 1.92	2.66 1.94 - 3.38
6–11	501	1.00	0.55 0.36 - 0.73	0.22 0.17 - 0.28	0.05 0.04 - 0.06	0.09 0.06 - 0.12	0.22 0.16 - 0.27	0.45 0.33 - 0.57	1.20 0.68 - 1.72	1.79 0.88 - 2.70
12–19	476	0.42	1.09 0.66 - 1.51	0.31 0.20 - 0.47	0.06 0.02 - 0.09	0.12 0.06 - 0.18	0.28 0.15 - 0.41	0.66 0.39 - 0.94	2.63 1.24 - 4.02	4.23 2.67 - 5.79
20–39	648	0.31	0.95 0.41 - 1.50	0.24 0.18 - 0.31	0.05 0.03 - 0.07	0.10 0.07 - 0.12	0.22 0.16 - 0.28	0.49 0.34 - 0.64	1.43 0.78 - 2.08	2.58 1.78 - 3.38
40–59	641	1.40	0.68 0.44 - 0.92	0.24 0.18 - 0.31	0.04 0.02 - 0.05	0.09 0.06 - 0.12	0.24 0.16 - 0.31	0.63 0.50 - 0.76	1.32 0.62 - 2.02	2.42 1.40 - 3.43
60–79	538	0.74	0.66 0.41 - 0.90	0.22 0.18 - 0.27	0.05 0.03 - 0.06	0.09 0.06 - 0.11	0.19 0.15 - 0.24	0.49 0.35 - 0.64	1.25 0.69 - 1.82	2.17 1.22 - 3.12

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.8.5b

3-Phenoxybenzoic acid (3-PBA) (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5436	0.61	0.91 0.65 - 1.17	0.31 0.25 - 0.37	0.08 0.06 - 0.09	0.14 0.12 - 0.16	0.27 0.21 - 0.32	0.58 0.44 - 0.73	1.64 1.18 - 2.09	2.86 2.31 - 3.41
6–11	1022	0.68	0.77 0.54 - 0.99	0.32 0.26 - 0.40	0.10 0.08 - 0.12	0.16 0.13 - 0.19	0.28 0.22 - 0.33	0.57 0.42 - 0.71	1.36 0.74 - 1.97	3.05 1.49 - 4.61
12–19	975	0.21	0.65 0.46 - 0.85	0.25 0.19 - 0.32	0.07 0.05 - 0.08	0.11 0.08 - 0.14	0.20 0.14 - 0.26	0.45 0.33 - 0.57	1.50 0.88 - 2.12	2.88 1.73 - 4.04
20–39	1155	0.35	0.98 0.49 - 1.48	0.28 0.22 - 0.35	0.07 0.05 - 0.09	0.13 0.10 - 0.16	0.24 0.18 - 0.29	0.51 0.39 - 0.64	1.37 0.76 - 1.98	2.40 1.56 - 3.24
40–59	1211	1.07	0.94 0.51 - 1.38	0.35 0.28 - 0.43	0.08 0.07 - 0.10	0.15 0.12 - 0.18	0.30 0.24 - 0.36	0.72 0.50 - 0.93	1.89 1.15 - 2.62	2.98 2.22 - 3.74
60–79	1073	0.65	0.94 0.61 - 1.28	0.34 0.28 - 0.40	0.09 0.08 - 0.10	0.15 0.13 - 0.17	0.30 0.24 - 0.35	0.62 0.42 - 0.82	1.58 0.95 - 2.20	3.07 1.99 - 4.16
Males										
Total, age 6–79	2637	0.42	0.91 0.49 - 1.32	0.27 0.22 - 0.32	0.07 0.07 - 0.08	0.12 0.10 - 0.14	0.23 0.18 - 0.27	0.50 0.39 - 0.61	1.35 0.84 - 1.87	2.53 1.96 - 3.10
6–11	522	0.38	0.80 0.43 - 1.16	0.31 0.24 - 0.39	0.10 0.08 - 0.12	0.15 0.12 - 0.18	0.25 0.19 - 0.31	0.52 0.36 - 0.68	1.14 <LOD - 2.78	3.13 <LOD - 5.23
12–19	500	0.00	0.52 0.26 - 0.78	0.22 0.17 - 0.29	0.06 0.05 - 0.08	0.10 0.08 - 0.12	0.18 0.12 - 0.24	0.41 0.25 - 0.58	1.13 0.46 - 1.81	1.88 0.93 - 2.82
20–39	509	0.39	1.03 <LOD - 1.87	0.24 0.19 - 0.31	0.07 0.06 - 0.09	0.12 0.09 - 0.14	0.19 0.15 - 0.24	0.39 0.29 - 0.50	0.94 0.41 - 1.48	1.98 0.98 - 2.98
40–59	571	0.70	0.97 0.15 - 1.78	0.30 0.23 - 0.38	0.07 0.06 - 0.09	0.12 0.10 - 0.15	0.25 0.18 - 0.32	0.64 0.44 - 0.85	1.70 <LOD - 2.80	2.75 1.13 - 4.38
60–79	535	0.56	0.87 0.43 - 1.31	0.28 0.23 - 0.33	0.08 0.06 - 0.09	0.13 0.10 - 0.16	0.25 0.19 - 0.31	0.52 0.40 - 0.64	1.35 0.88 - 1.82	2.27 1.51 - 3.03
Females										
Total, age 6–79	2799	0.79	0.91 0.71 - 1.12	0.36 0.29 - 0.44	0.10 0.08 - 0.12	0.16 0.13 - 0.19	0.31 0.25 - 0.36	0.67 0.48 - 0.87	1.87 1.43 - 2.31	3.31 2.62 - 4.00
6–11	500	1.00	0.73 0.50 - 0.97	0.35 0.27 - 0.44	0.10 0.06 - 0.13	0.17 0.14 - 0.20	0.31 0.25 - 0.37	0.60 0.39 - 0.81	1.53 0.86 - 2.19	2.60 0.49 - 4.72
12–19	475	0.42	0.80 0.49 - 1.10	0.28 0.20 - 0.38	0.07 0.05 - 0.09	0.13 0.08 - 0.18	0.21 0.14 - 0.29	0.47 0.35 - 0.60	1.59 <LOD - 3.34	3.93 2.39 - 5.46
20–39	646	0.31	0.93 0.58 - 1.28	0.32 0.25 - 0.42	0.09 0.05 - 0.12	0.16 0.12 - 0.19	0.29 0.22 - 0.36	0.59 0.45 - 0.73	1.70 1.18 - 2.23	3.08 1.75 - 4.40
40–59	640	1.41	0.92 0.72 - 1.12	0.40 0.32 - 0.49	0.11 0.09 - 0.13	0.18 0.14 - 0.23	0.34 0.27 - 0.40	0.78 0.47 - 1.08	2.02 1.47 - 2.57	3.04 2.34 - 3.74
60–79	538	0.74	1.01 0.67 - 1.35	0.40 0.32 - 0.50	0.11 0.10 - 0.13	0.17 0.14 - 0.21	0.34 0.25 - 0.42	0.77 0.51 - 1.03	1.99 0.86 - 3.11	3.70 1.42 - 5.98

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.9 PHENOXY HERBICIDE

8.9.1 2,4-Dichlorophenoxyacetic Acid (2,4-D) (CASRN 94-75-7)

The pesticide 2,4-dichlorophenoxyacetic acid (2,4-D) is a selective herbicide used for the control of broadleaf weeds in residential, agricultural and forest environments. 2,4-D is the most common chemical in the class of phenoxy herbicides. 2,4-D was first registered in Canada in 1946 for agricultural and forestry use and has been permitted for use on lawns and turf since the 1960s. In products, it is often combined with other herbicides, including dicamba and mecoprop-p, as well as fertilizers. 2,4-D is found in over 150 agricultural and residential products in Canada (Health Canada, 2009a).

Historically, 2,4-D has been associated with Agent Orange and dioxins. Agent Orange was a defoliant used during the Vietnam War that contained 2,4-D and a second herbicide, 2,4,5-T. Agent Orange was never registered for use in Canada; however, it was used briefly in an experimental capacity at the Gagetown military base in Canada in the 1960s (National Defence, 2009). 2,4,5-T was withdrawn from the market in the early 1980s, in part, because of concerns with dioxins (PMRA, 2008). As a result of refinements in the manufacturing process since the 1980s, only trace levels of dioxins remain in 2,4-D products (PMRA, 2008).

The public may be primarily exposed to 2,4-D through ingestion of residues in water and treated crops, while handling products containing 2,4-D, and by entering areas such as turf previously treated with 2,4-D (PMRA, 2008). Exposure can occur through oral, dermal, and inhalation routes. Increased levels of occupational exposure have been observed in individuals working in the manufacture and application of phenoxy herbicides (ATSDR, 1999). 2,4-D is a relatively short-lived chemical in terrestrial and aquatic environments, with a half-life of less than two weeks, except in anaerobic environments where 2,4-D is persistent. This highly mobile chemical is susceptible to leaching and runoff from treated areas (PMRA, 2007).

Following entry into the body, 2,4-D is rapidly absorbed and excreted primarily unchanged in urine and to a lesser extent in the feces. Accumulation in tissues is low. 2,4-D has an elimination half-life of 10 to 33 hours (CDC, 2005). 2,4-D has been routinely measured in urine by researchers and its presence in urine is reflective of exposure over the previous few days. 2,4-D has been measured in other biological matrices including semen and plasma (Arbuckle, 1999; Barr & Needham, 2002).

Long-term exposure to 2,4-D has been associated with effects on the kidneys, nervous system, and body weights in animal studies; the primary target organ for toxicity is the kidney (PMRA, 2007). Some studies have suggested associations between occupational use of phenoxy herbicides and cancer, including non-Hodgkin's lymphoma and soft tissue sarcomas; however, these studies are complicated by confounding factors and exposures to other pesticides, and other studies have not shown an association (IARC 1987; IARC, 1999; ATSDR, 1999; WHO, 2003a; WHO, 2003b; PMRA, 2008). Although there has been some debate in the scientific community regarding the carcinogenicity potential of 2,4-D, recent re-evaluations by the Pest Management Regulatory Agency, the European Union, the United States Environmental Protection Agency, New Zealand, and the World Health Organization do not classify 2,4-D as a human carcinogen (PMRA, 2006).

The sale and use of 2,4-D is regulated in Canada by the Pest Management Regulatory Agency (PMRA). The PMRA evaluates the toxicity of pesticides and potential exposure in order to determine whether a pesticide should be approved for a specific use. In the most recent re-evaluation by the PMRA in 2008, it was determined that there were no unacceptable health risks posed to the public from products containing 2,4-D. As part of the approval process, the PMRA established maximum residue limits (MRLs) for 2,4-D in various foods, ranging from 0.5 to 5.0 ppm (Health Canada, 2009b). Many municipalities and provinces have imposed further restrictions or bans on the use of 2,4-D on lawns to address local concerns regarding use of pesticides for cosmetic or aesthetic purposes.

In 1996, 2,4-D was measured in 24-hour urine samples from Ontario farmers and farm families as part of the Ontario Farm Family Health Study and the Pesticide Exposure Assessment Pilot Study. In farmers (n=97), mean semen concentrations were 29.8 µg/L and mean urinary concentrations were 26.6 µg/L (Arbuckle et al., 1999). Geometric mean urinary concentrations ranged from 0.7 to 9.9 µg/L in farm applicators (n = 126), 0.55 to 0.66 µg/L in women (n ranged from 115 to 125), and 0.7 to 2.9 µg/L in children aged 3 to 18 (n = 89) (Arbuckle et al., 2005; Arbuckle and Ritter, 2005; Arbuckle et al., 2004). Urinary levels of 2,4-D were measured in morning voids from 123 children aged 3 to 7 years in Québec in 2003. Only six samples had detectable levels, with a geometric mean and maximum of 13.9 and 40 µg/g creatinine (INSPQ, 2004).

2,4-D was measured in urine in all CHMS participants aged 6–79 years and is presented as µg/L urine and µg/g creatinine (Tables 8.9.1a, 8.9.1b). Although a measurable amount of 2,4-D in urine is evidence of exposure to the herbicide, it does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for urinary levels of 2,4-D in the Canadian population.

Table 8.9.1a

2,4-Dichlorophenoxyacetic acid (2,4-D) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5480	95.31	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
6–11	1030	95.73	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
12–19	981	95.82	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	1166	96.74	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	1222	95.17	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	1.03 <LOD - 1.28
60–79	1081	93.06	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	1.18 <LOD - 1.70
Males										
Total, age 6–79	2661	94.63	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	1.08 <LOD - 1.37
6–11	525	95.43	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	1.01 <LOD - 1.37
12–19	504	96.03	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	513	94.93	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	578	94.64	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	1.15 <LOD - 1.47
60–79	541	92.24	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	1.40 <LOD - 2.02
Females										
Total, age 6–79	2819	95.98	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
6–11	505	96.04	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
12–19	477	95.60	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	653	98.16	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	644	95.65	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	540	93.89	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.9.1b

2,4-Dichlorophenoxyacetic acid (2,4-D) (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5466	95.55	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
6–11	1027	96.01	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
12–19	979	96.02	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	1162	97.07	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	1217	95.56	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	2.94 <LOD - 3.27
60–79	1081	93.06	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	3.01 <LOD - 3.58
Males										
Total, age 6–79	2652	94.95	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	2.30 <LOD - 2.79
6–11	523	95.79	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	3.21 <LOD - 4.52
12–19	503	96.22	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	511	95.30	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	574	95.30	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	2.22 <LOD - 2.75
60–79	541	92.24	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	1.84 <LOD - 2.14
Females										
Total, age 6–79	2814	96.13	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
6–11	504	96.23	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
12–19	476	95.80	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
20–39	651	98.46	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
40–59	643	95.80	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
60–79	540	93.89	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.10 CHLOROPHENOL

8.10.1 2,4-Dichlorophenol (2,4-DCP) (CASRN 120-83-2)

2,4-dichlorophenol (2,4-DCP) is a part of the chlorophenol group of chemicals. Chlorophenols are the building blocks of many chlorinated aromatic chemicals including pesticides and pharmaceuticals. Chlorophenols are metabolites of many chlorinated substances used in occupational settings and of chlorinated substances commonly found in the environment.

2,4-DCP is not naturally present in the environment, and the only sources are anthropogenic. The principal use of 2,4-DCP is as an intermediate in the production of phenoxy herbicides, specifically 2,4-D (DowAgroSciences, 2000). 2,4-DCP is a minor metabolite of 2,4-D in aquatic environments and to a lesser extent in soil; it is not a human metabolite of 2,4-D (PMRA, 2007).

2,4-DCP can enter the environment through its use in the manufacture of pesticides and pharmaceuticals, through chlorination of organic material in wastewaters, from the incineration of organochlorine-containing wastes, and from the degradation of 2,4-D and other chlorinated compounds (ATSDR, 1999; PMRA, 2007). In the environment, 2,4-DCP will likely enter water, but will degrade into smaller organic molecules until finally mineralized into carbon dioxide and water over a few weeks (ATSDR, 1999; PMRA, 2007). 2,4-DCP has been detected downstream of wastewater plants (ATSDR, 1999).

Primary exposure to 2,4-DCP for the general population is a result of uptake from the environment through water (ATSDR, 1999). 2,4-DCP is well absorbed through oral, dermal, and inhalation routes of exposure (CDC, 2005). 2,4-DCP has been measured in urine and its presence is reflective of recent exposures to 2,4-DCP and other chlorinated aromatic chemicals (Angerer et al., 1992; ATSDR, 1999).

Symptoms of exposure to very high doses of 2,4-DCP include convulsions, lethargy, tremors, and central nervous system depression. Long-term exposure to 2,4-DCP may be associated with effects on the liver and immune system, as well as skin acne (ATSDR, 1999).

2,4-DCP was measured in urine in all CHMS participants aged 6–79 years and are presented as µg/L urine and µg/g creatinine (Tables 8.10.1a, 8.10.1b). Although a measurable amount of 2,4-DCP in urine is evidence of exposure, it does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for urinary levels of 2,4-DCP in the Canadian population.

Table 8.10.1a

2,4-Dichlorophenol (2,4-DCP) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5479	21.81	2.41 2.10 - 2.72	0.88 0.77 - 1.01	<LOD	0.33 <LOD - 0.39	0.83 0.69 - 0.97	2.25 1.88 - 2.63	5.33 4.36 - 6.30	8.92 7.73 - 10.12
6–11	1029	22.35	2.57 1.85 - 3.28	0.83 0.67 - 1.03	<LOD	0.34 <LOD - 0.43	0.74 0.63 - 0.85	1.77 1.30 - 2.24	4.73 2.78 - 6.68	9.37 3.03 - 15.72
12–19	981	17.02	3.00 2.32 - 3.67	1.03 0.84 - 1.25	<LOD	0.40 0.30 - 0.49	0.98 0.76 - 1.19	2.44 2.01 - 2.86	5.91 4.31 - 7.52	12.96 9.68 - 16.25
20–39	1166	22.04	2.11 1.82 - 2.41	0.89 0.77 - 1.03	<LOD	0.35 <LOD - 0.42	0.90 0.72 - 1.09	2.25 1.82 - 2.69	4.81 3.62 - 5.99	7.28 5.78 - 8.78
40–59	1222	24.06	2.32 1.78 - 2.85	0.84 0.74 - 0.95	<LOD	0.30 <LOD - 0.36	0.76 0.61 - 0.92	2.23 1.83 - 2.63	5.49 4.14 - 6.85	8.95 7.44 - 10.47
60–79	1081	22.85	2.68 2.00 - 3.36	0.88 0.71 - 1.09	<LOD	0.35 <LOD - 0.43	0.78 0.56 - 1.00	2.32 1.57 - 3.08	5.88 4.03 - 7.72	10.22 6.32 - 14.12
Males										
Total, age 6–79	2661	18.90	2.55 2.20 - 2.90	0.99 0.86 - 1.14	<LOD	0.39 0.32 - 0.45	0.97 0.79 - 1.14	2.45 2.06 - 2.84	5.65 4.19 - 7.12	9.16 7.76 - 10.55
6–11	525	23.05	2.00 1.49 - 2.51	0.79 0.61 - 1.03	<LOD	<LOD <LOD - 0.54	0.73 0.56 - 0.90	1.88 1.37 - 2.40	4.34 3.17 - 5.51	7.79 4.83 - 10.75
12–19	504	15.28	2.93 2.11 - 3.76	1.05 0.86 - 1.29	<LOD	0.40 0.30 - 0.50	1.01 0.77 - 1.26	2.68 2.06 - 3.30	6.58 3.89 - 9.27	12.94 8.71 - 17.17
20–39	513	19.10	2.35 1.82 - 2.88	0.97 0.79 - 1.20	<LOD	0.36 <LOD - 0.47	1.04 0.77 - 1.31	2.44 1.72 - 3.16	5.08 3.60 - 6.56	8.07 5.64 - 10.50
40–59	578	18.17	2.46 1.75 - 3.17	0.99 0.85 - 1.15	<LOD	0.38 0.30 - 0.46	0.90 0.66 - 1.14	2.45 2.00 - 2.91	6.39 4.25 - 8.52	9.44 7.77 - 11.11
60–79	541	18.85	3.09 2.09 - 4.10	1.08 0.84 - 1.38	<LOD	0.44 0.34 - 0.55	0.95 0.62 - 1.29	2.69 1.91 - 3.47	6.26 3.48 - 9.05	11.65 5.64 - 17.66
Females										
Total, age 6–79	2818	24.56	2.27 1.90 - 2.64	0.79 0.68 - 0.91	<LOD	<LOD	0.72 0.61 - 0.83	1.95 1.53 - 2.37	4.86 3.99 - 5.72	8.53 6.80 - 10.27
6–11	504	21.63	3.17 1.91 - 4.43	0.88 0.71 - 1.09	<LOD	0.36 <LOD - 0.44	0.74 0.64 - 0.85	1.65 1.10 - 2.20	5.66 1.23 - 10.08	11.79 <LOD - 25.91
12–19	477	18.87	3.07 2.12 - 4.01	1.00 0.76 - 1.30	<LOD	0.37 <LOD - 0.54	0.92 0.65 - 1.20	2.26 1.54 - 2.98	5.44 2.37 - 8.50	12.83 4.95 - 20.71
20–39	653	24.35	1.88 1.48 - 2.28	0.81 0.69 - 0.95	<LOD	0.32 <LOD - 0.41	0.78 0.62 - 0.93	2.04 1.48 - 2.60	4.29 2.89 - 5.69	6.96 5.01 - 8.92
40–59	644	29.35	2.18 1.75 - 2.60	0.72 0.62 - 0.83	<LOD	<LOD	0.63 0.51 - 0.76	1.95 1.39 - 2.52	4.83 3.91 - 5.74	8.59 6.42 - 10.75
60–79	540	26.85	2.31 1.59 - 3.02	0.74 0.58 - 0.94	<LOD	<LOD	0.62 0.46 - 0.79	1.75 0.94 - 2.57	5.73 4.04 - 7.42	9.23 6.04 - 12.42

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.10.1b

2,4-Dichlorophenol (2,4-DCP) (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	5465	21.87	2.82 2.29 - 3.35	1.07 0.94 - 1.21	<LOD	0.45 <LOD - 0.50	0.92 0.76 - 1.07	2.39 1.92 - 2.86	5.81 4.84 - 6.78	9.67 8.01 - 11.32
6–11	1026	22.42	3.39 2.50 - 4.28	1.28 1.06 - 1.56	<LOD	0.52 <LOD - 0.64	1.14 0.88 - 1.40	2.57 1.98 - 3.17	7.13 4.23 - 10.02	13.94 7.07 - 20.81
12–19	979	17.06	2.27 1.84 - 2.71	0.89 0.79 - 1.01	<LOD	0.40 0.34 - 0.46	0.78 0.65 - 0.91	1.76 1.39 - 2.13	5.56 4.09 - 7.03	9.42 7.07 - 11.77
20–39	1162	22.12	2.09 1.78 - 2.41	0.99 0.88 - 1.13	<LOD	0.43 <LOD - 0.50	0.88 0.65 - 1.10	2.17 1.79 - 2.55	4.77 4.01 - 5.54	8.02 6.17 - 9.87
40–59	1217	24.16	2.88 2.28 - 3.47	1.07 0.94 - 1.23	<LOD	0.45 <LOD - 0.53	0.85 0.73 - 0.97	2.57 1.85 - 3.28	6.37 5.18 - 7.56	10.17 6.94 - 13.40
60–79	1081	22.85	4.14 2.53 - 5.75	1.24 0.99 - 1.55	<LOD	0.47 <LOD - 0.57	1.07 0.77 - 1.36	2.88 2.11 - 3.65	6.97 4.21 - 9.72	12.15 6.98 - 17.32
Males										
Total, age 6–79	2652	18.97	2.36 2.03 - 2.70	0.98 0.86 - 1.11	<LOD	0.41 0.34 - 0.48	0.84 0.70 - 0.99	2.10 1.60 - 2.61	5.29 4.37 - 6.21	8.29 6.93 - 9.64
6–11	523	23.14	2.72 2.07 - 3.37	1.19 0.98 - 1.45	<LOD	<LOD <LOD - 0.70	1.17 0.90 - 1.44	2.33 1.77 - 2.88	4.81 3.54 - 6.08	10.52 6.49 - 14.54
12–19	503	15.31	2.08 1.55 - 2.62	0.89 0.75 - 1.05	<LOD	0.35 <LOD - 0.44	0.81 0.64 - 0.98	1.90 1.41 - 2.40	4.95 3.29 - 6.61	8.46 4.24 - 12.68
20–39	511	19.18	1.97 1.58 - 2.35	0.90 0.75 - 1.07	<LOD	0.39 <LOD - 0.47	0.78 0.56 - 1.00	2.01 1.38 - 2.63	4.89 3.76 - 6.03	8.01 6.16 - 9.86
40–59	574	18.29	2.27 1.74 - 2.80	0.97 0.83 - 1.13	<LOD	0.40 <LOD - 0.50	0.82 0.70 - 0.94	1.98 1.13 - 2.83	5.66 3.87 - 7.45	7.52 3.85 - 11.18
60–79	541	18.85	3.34 2.14 - 4.54	1.13 0.91 - 1.41	<LOD	0.45 0.36 - 0.53	0.99 0.61 - 1.37	2.81 2.03 - 3.59	5.88 3.76 - 8.00	10.77 7.20 - 14.35
Females										
Total, age 6–79	2813	24.60	3.27 2.40 - 4.15	1.17 1.02 - 1.34	<LOD	<LOD	0.97 0.78 - 1.16	2.57 2.10 - 3.04	6.17 4.80 - 7.54	10.80 7.41 - 14.19
6–11	503	21.67	4.10 2.53 - 5.68	1.38 1.08 - 1.77	<LOD	0.51 <LOD - 0.62	1.11 0.78 - 1.43	2.96 1.77 - 4.15	8.90 5.27 - 12.53	18.58 <LOD - 33.55
12–19	476	18.91	2.48 1.84 - 3.12	0.90 0.76 - 1.07	<LOD	0.43 <LOD - 0.47	0.77 0.60 - 0.94	1.57 0.97 - 2.17	5.90 3.38 - 8.42	9.53 6.77 - 12.28
20–39	651	24.42	2.22 1.78 - 2.66	1.10 0.94 - 1.29	<LOD	0.46 <LOD - 0.55	1.00 0.71 - 1.28	2.39 1.74 - 3.04	4.75 3.64 - 5.87	8.29 5.26 - 11.33
40–59	643	29.39	3.48 2.41 - 4.54	1.19 1.00 - 1.41	<LOD	<LOD	0.90 0.70 - 1.10	2.71 2.24 - 3.18	6.76 5.17 - 8.34	13.08 7.17 - 18.99
60–79	540	26.85	4.87 2.17 - 7.57	1.35 1.06 - 1.72	<LOD	<LOD	1.09 0.83 - 1.35	2.88 1.83 - 3.94	7.58 3.70 - 11.45	14.52 6.89 - 22.15

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.11 TOBACCO

8.11.1 Cotinine (CASRN 486-56-6)

Cotinine, also known as 1-methyl-5-(3-pyridinyl)-2-pyrrolidinone, (S)-1-methyl-5-(3-pyridinyl)-2-pyrrolidinone, and S-(-)-cotinine, is the primary metabolite of nicotine, a chemical commonly found in tobacco products. It is considered to be the best biomarker for exposure to tobacco products and tobacco smoke, with the level of cotinine in blood or urine providing an indication of the level of exposure to tobacco smoke (CDC, 2009; Brown et al., 2005).

Cotinine is not produced directly by the tobacco plant, but rather is a metabolic product of nicotine. Nicotine is found naturally in tobacco plants and as a result is present in tobacco products, such as cigarettes, cigars, smokeless tobacco products (chewing tobacco and snuff), and, after extraction from tobacco, is added to nicotine replacement therapies (nicotine gum and patch). Canadian cigarettes contain on average 12.6 mg nicotine per cigarette and release between 0.9 and 2.4 mg nicotine per cigarette in mainstream smoke emissions when measured under standard smoking machine conditions (Hammond & O'Connor, 2008).

The most likely routes of human exposure to nicotine are either directly by smoking cigarettes or through use of other tobacco products, or, indirectly, through exposure to second-hand smoke (NLM, 2008). In addition, infants breast-fed by women who smoke may be exposed to nicotine in breast milk (NLM, 2008). For adults, other possible routes of nicotine exposure include occupational exposure for individuals involved in tobacco product manufacturing, and dietary ingestion of nicotine in chewing tobacco, nicotine gum, and some foods (tomatoes, potatoes, eggplants), although this last source is very small when compared to tobacco (Davis et al., 1991; Sheen, 1988).

Respiratory absorption is the most effective intake route, as on average 60–80% of nicotine is absorbed through the lungs; nicotine can also be absorbed through the skin and gastrointestinal tract, but at a much lower efficiency (Iwase et al., 1991; Karaconji, 2005). Once inside the body, approximately 70–80% of nicotine is metabolized into cotinine, which has a half-life of 10–20 hours and can remain in the body at detectable levels for up to four days (Benowitz & Jacob, 1994; Curvall et al., 1990). As a biomarker of exposure to tobacco products and tobacco smoke, levels of cotinine in the blood and urine are also well correlated with the toxic effects of other substances found in tobacco smoke (Benowitz, 1996).

Tobacco smoke is a combination of gases, liquids, and breathable particles, some of which are harmful to health. It contains over 4000 chemicals, including at least 50 that cause, initiate, or promote cancer (NCI, 2008; IARC, 2004). Exposure to these chemicals also contributes directly to other diseases, such as asthma, heart disease, and emphysema (DHHS, 2004). Most of these chemicals are formed during the combustion of the tobacco; others are found naturally in the tobacco and are released as the tobacco burns (DHHS, 2004). Smokeless tobaccos, including chewing tobacco and snuff, contain many of the same harmful and addictive substances as the tobaccos used in cigarettes, pipes, and cigars. Smokeless tobacco use is a major cause of cancer of the mouth and throat. It can also cause serious dental health problems, including recession of the gums, tooth loss, and discolouration of the teeth and gums (Walsh & Epstein, 2000). Cotinine itself may be responsible for the central nervous system effects (mood elevation, arousal, locomotor stimulant effects, and learning and memory enhancement) commonly attributed to nicotine (Crooks & Dwoskin, 1997).

As a result of the adverse effects of tobacco smoke, including second-hand smoke or environmental tobacco smoke, the Government of Canada, along with various provincial and municipal governments, has taken several steps to reduce exposure to tobacco smoke, particularly involuntary exposure. These steps include restrictions on the sale and advertising of tobacco products (Health Canada, 2007), along with initiatives to reduce or eliminate smoking in workplaces and other public locations.

Measurement of cotinine in urine is often used as a biomarker of exposure to tobacco smoke. A study in 1992 of 232 anglers in two regions of the Great

Lakes area of Ontario showed non-smokers to have a median cotinine level of 12.4 µg/g creatinine, while smokers had a median cotinine level of 2583.7 µg/g creatinine (Kearney et al., 1995).

Cotinine was measured in the urine of all CHMS participants aged 6–79 years, and is presented as µg/L urine and µg/g creatinine (Tables 8.11.1a, 8.11.1b, 8.11.1c, 8.11.1d). Survey participants aged 6–11 years were assumed to be non-smokers. In this survey a smoker is defined as someone who is a current daily or occasional smoker and a non-smoker is defined as someone who does not currently smoke and has either never smoked or who was previously a daily or occasional smoker. Finding a measurable amount of cotinine in urine is an indicator of exposure to nicotine and does not necessarily mean that an adverse health effect will occur. These data provide reference ranges for urinary levels of cotinine in the Canadian population.

Table 8.11.1a

Cotinine (non-smokers) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the non-smoking Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	4704	85.84	—	—	<LOD	<LOD	<LOD	<LOD	3.31 1.61 - 5.01	11.77 <LOD - 24.33
6–11	1045	83.83	—	—	<LOD	<LOD	<LOD	<LOD	3.92 1.96 - 5.88	10.36 5.75 - 14.96
12–19	882	80.27	—	—	<LOD	<LOD	<LOD	<LOD	8.28 3.67 - 12.88	19.10 8.38 - 29.82
20–39	874	85.35	—	—	<LOD	<LOD	<LOD	<LOD	4.02 <LOD - 7.72	22.96 <LOD - 176.66
40–59	947	88.81	—	—	<LOD	<LOD	<LOD	<LOD	2.00 <LOD - 4.42	10.32 <LOD - 20.81
60–79	956	90.69	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	4.80 <LOD - 9.92
Males										
Total, age 6–79	2252	82.95	—	—	<LOD	<LOD	<LOD	<LOD	4.38 1.73 - 7.02	18.06 <LOD - 66.45
6–11	528	82.39	—	—	<LOD	<LOD	<LOD	<LOD	4.90 2.02 - 7.79	10.22 5.72 - 14.72
12–19	452	77.65	—	—	<LOD	<LOD	<LOD	<LOD <LOD - 3.46	7.93 <LOD - 15.04	26.54 1.41 - 51.67
20–39	367	82.83	—	—	<LOD	<LOD	<LOD	<LOD	3.82 <LOD - 10.25	34.13 <LOD - 173.04
40–59	436	83.94	—	—	<LOD	<LOD	<LOD	<LOD	4.34 <LOD - 9.12	25.02 <LOD - 154.11
60–79	469	87.85	—	—	<LOD	<LOD	<LOD	<LOD	1.97 <LOD - 3.32	5.22 <LOD - 19.57
Females										
Total, age 6–79	2452	88.50	—	—	<LOD	<LOD	<LOD	<LOD	2.36 <LOD - 4.19	9.93 3.38 - 16.48
6–11	517	85.30	—	—	<LOD	<LOD	<LOD	<LOD	3.71 <LOD - 6.77	10.42 1.20 - 19.64
12–19	430	83.02	—	—	<LOD	<LOD	<LOD	<LOD	8.34 3.17 - 13.50	13.60 5.17 - 22.02
20–39	507	87.18	—	—	<LOD	<LOD	<LOD	<LOD	3.99 <LOD - 7.68	18.15 <LOD - 241.80
40–59	511	92.95	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	7.49 <LOD - 14.11
60–79	487	93.43	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	2.98 <LOD - 17.18

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.11.1b

Cotinine (non-smokers) (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the non-smoking Canadian population aged 6–79 years, Canadian Health Measures Survey Cycle 1, 2007–2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 6–79	4694	86.02	—	—	<LOD	<LOD	<LOD	<LOD	4.76 3.58 - 5.93	15.31 <LOD - 31.49
6–11	1042	84.07	—	—	<LOD	<LOD	<LOD	<LOD	6.65 2.30 - 11.00	14.42 2.73 - 26.12
12–19	881	80.36	—	—	<LOD	<LOD	<LOD	<LOD	7.89 4.71 - 11.07	14.50 1.54 - 27.46
20–39	871	85.65	—	—	<LOD	<LOD	<LOD	<LOD	4.71 <LOD - 7.35	24.92 <LOD - 158.83
40–59	944	89.09	—	—	<LOD	<LOD	<LOD	<LOD	4.87 <LOD - 6.53	14.65 <LOD - 27.20
60–79	956	90.69	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	6.57 <LOD - 13.08
Males										
Total, age 6–79	2246	83.17	—	—	<LOD	<LOD	<LOD	<LOD	4.86 2.72 - 7.00	20.39 <LOD - 63.25
6–11	526	82.70	—	—	<LOD	<LOD	<LOD	<LOD	5.96 <LOD - 11.36	15.36 1.37 - 29.35
12–19	451	77.83	—	—	<LOD	<LOD	<LOD	<LOD <LOD - 2.59	8.78 <LOD - 13.61	32.22 <LOD - 68.17
20–39	366	83.06	—	—	<LOD	<LOD	<LOD	<LOD	4.68 <LOD - 7.88	26.72 <LOD - 130.51
40–59	434	84.33	—	—	<LOD	<LOD	<LOD	<LOD	4.76 <LOD - 8.53	25.65 <LOD - 120.81
60–79	469	87.85	—	—	<LOD	<LOD	<LOD	<LOD	2.50 <LOD - 3.60	6.82 <LOD - 16.41
Females										
Total, age 6–79	2448	88.64	—	—	<LOD	<LOD	<LOD	<LOD	4.72 <LOD - 5.93	12.23 2.04 - 22.43
6–11	516	85.47	—	—	<LOD	<LOD	<LOD	<LOD	6.68 <LOD - 10.84	13.83 2.52 - 25.14
12–19	430	83.02	—	—	<LOD	<LOD	<LOD	<LOD	6.41 2.96 - 9.86	9.46 3.34 - 15.58
20–39	505	87.52	—	—	<LOD	<LOD	<LOD	<LOD	4.69 <LOD - 10.48	22.84 <LOD - 211.79
40–59	510	93.14	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	8.40 <LOD - 19.23
60–79	487	93.43	—	—	<LOD	<LOD	<LOD	<LOD	<LOD	5.73 <LOD - 31.08

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.11.1c

Cotinine (smokers) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/L) for the smoking Canadian population aged 12–79 years, Canadian Health Measures Survey Cycle 1, 2007-2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 12–79	805	4.22	1142.80 985.80 - 1299.79	589.09 422.48 - 821.41	73.43 <LOD - 181.79	462.31 275.62 - 648.99	1063.82 814.04 - 1313.61	1674.90 1473.65 - 1876.14	2258.76 2083.11 - 2434.41	2627.95 2295.86 - 2960.04
12–19	102	10.78	689.39 514.21 - 864.57	161.10 72.27 - 359.15	1.36 <LOD - 11.42	29.71 <LOD - 106.31	416.19 <LOD - 853.50	1256.81 961.41 - 1552.21	1682.39 1382.30 - 1982.48	S
20–39	300	3.00	1042.76 873.81 - 1211.71	501.58 307.17 - 819.04	68.42 <LOD - 174.11	378.70 145.15 - 612.25	929.98 605.64 - 1254.33	1572.89 1403.57 - 1742.22	2074.45 1864.78 - 2284.11	2540.84 2170.14 - 2911.55
40–59	275	3.27	1322.04 1098.05 - 1546.03	832.66 607.60 - 1141.09	191.39 12.53 - 370.25	645.00 438.53 - 851.47	1252.07 941.36 - 1562.77	1901.90 1522.44 - 2281.36	2498.37 2196.47 - 2800.27	2788.24 2428.76 - 3147.73
60–79	128	3.91	1118.44 937.30 - 1299.57	653.76 427.06 - 1000.80	142.23 <LOD - 361.96	505.51 259.29 - 751.74	859.61 590.42 - 1128.80	1631.16 1378.88 - 1883.44	2229.21 1983.95 - 2474.47	S
Males										
Total, age 12–79	406	4.43	1289.82 1072.32 - 1507.33	658.77 405.23 - 1070.92	68.41 <LOD - 337.18	614.51 357.33 - 871.70	1250.61 949.30 - 1551.91	1868.46 1596.64 - 2140.28	2338.73 2009.76 - 2667.71	2859.42 2421.72 - 3297.12
12–19	48	12.50	805.98 413.15 - 1198.81	200.44 38.63 - 1039.97	S	115.79 <LOD - 408.96	679.01 93.50 - 1264.52	1286.34 812.92 - 1759.75	S	S
20–39	149	2.68	1088.04 815.40 - 1360.68	514.69 246.49 - 1074.70	51.79 <LOD - 368.64	424.28 71.60 - 776.95	885.54 408.33 - 1362.75	1585.93 1276.68 - 1895.17	2043.49 1740.11 - 2346.86	S
40–59	140	3.57	1577.61 1289.68 - 1865.55	980.37 603.05 - 1593.78	224.44 <LOD - 686.94	957.19 501.35 - 1413.03	1596.08 1199.77 - 1992.40	2095.75 1890.55 - 2300.96	2580.20 2125.57 - 3034.83	S
60–79	69	4.35	1379.47 1130.08 - 1628.86	908.61 638.20 - 1293.60	S	698.56 337.94 - 1059.18	1342.63 781.19 - 1904.07	1754.58 1320.46 - 2188.71	S	S
Females										
Total, age 12–79	399	4.01	974.93 846.57 - 1103.29	518.50 386.99 - 694.71	95.55 15.81 - 175.30	341.85 155.22 - 528.47	864.92 636.79 - 1093.04	1366.33 1126.25 - 1606.40	2115.64 1872.75 - 2358.52	2517.08 2314.18 - 2719.98
12–19	54	9.26	577.62 263.26 - 891.98	130.66 65.34 - 261.28	S	24.40 <LOD - 55.97	260.43 <LOD - 854.41	1125.57 270.19 - 1980.96	S	S
20–39	151	3.31	978.72 851.44 - 1105.99	483.61 334.75 - 698.66	102.48 17.93 - 187.03	216.34 11.23 - 421.46	945.85 573.90 - 1317.80	1425.34 1111.23 - 1739.45	2181.91 1817.53 - 2546.30	S
40–59	135	2.96	1064.68 893.11 - 1236.26	706.40 526.73 - 947.35	185.08 <LOD - 398.92	526.39 282.61 - 770.17	920.43 657.95 - 1182.91	1313.26 922.18 - 1704.34	2219.02 1759.98 - 2678.06	S
60–79	59	3.39	877.03 613.27 - 1140.79	482.18 265.98 - 874.13	S	331.61 51.47 - 611.75	665.38 430.22 - 900.53	1157.43 535.27 - 1779.58	S	S

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

S Any estimate based on fewer than the minimum number of respondents required according to the *Statistics Act* must be suppressed in order to ensure respondent confidentiality. See Section 6.0, Statistical Data Analysis, for further information.

Table 8.11.1d

Cotinine (smokers) (creatinine adjusted) – Arithmetic and geometric means, and selected percentiles of urine concentrations (µg/g creatinine) for the smoking Canadian population aged 12–79 years, Canadian Health Measures Survey Cycle 1, 2007-2009.

	n	%<LOD[a]	A.M. 95%CI	G.M. 95%CI	10th 95%CI	25th 95%CI	50th 95%CI	75th 95%CI	90th 95%CI	95th 95%CI
Total, age 12–79	803	4.23	1417.20 1200.64 - 1633.75	655.59 483.91 - 888.18	75.70 <LOD - 213.95	473.54 303.44 - 643.64	1051.30 838.18 - 1264.41	1825.71 1533.22 - 2118.19	3042.01 2518.74 - 3565.28	4440.73 3503.51 - 5377.96
12–19	102	10.78	480.60 321.22 - 639.99	121.47 53.53 - 275.63	1.27 <LOD - 11.47	46.06 <LOD - 118.34	287.25 <LOD - 473.07	663.69 337.77 - 989.60	1452.65 592.05 - 2313.25	S
20–39	299	3.01	1081.97 868.23 - 1295.71	512.64 320.08 - 821.03	56.95 <LOD - 206.74	357.34 135.55 - 579.13	850.06 530.68 - 1169.44	1436.47 1144.33 - 1728.60	2272.72 1893.69 - 2651.75	2507.92 2004.10 - 3011.74
40–59	275	3.27	1872.13 1514.80 - 2229.46	1035.36 811.60 - 1320.81	266.39 68.00 - 464.79	775.93 594.55 - 957.30	1276.36 916.26 - 1636.46	2541.96 1861.11 - 3222.81	4162.04 2917.08 - 5406.99	5528.63 4477.94 - 6579.33
60–79	127	3.94	1529.24 1159.67 - 1898.82	842.47 518.19 - 1369.71	118.61 <LOD - 480.92	637.60 387.22 - 887.97	1294.86 1058.24 - 1531.48	1863.47 1450.31 - 2276.62	3255.28 2151.75 - 4358.81	S
Males										
Total, age 12–79	405	4.44	1177.62 946.03 - 1409.21	561.49 361.23 - 872.77	57.68 <LOD - 226.91	462.47 217.99 - 706.94	929.56 641.80 - 1217.31	1542.99 1297.99 - 1787.99	2331.01 1899.79 - 2762.23	3357.39 2407.11 - 4307.66
12–19	48	12.50	590.79 216.46 - 965.11	149.98 30.66 - 733.57	S	56.63 <LOD - 258.55	357.12 <LOD - 747.67	799.59 <LOD - 1804.97	S	S
20–39	148	2.70	902.07 688.48 - 1115.65	419.28 234.16 - 750.77	49.01 <LOD - 203.35	276.07 37.05 - 515.09	633.14 356.58 - 909.69	1235.96 1042.92 - 1429.00	1807.58 1321.86 - 2293.31	S
40–59	140	3.57	1504.87 1136.05 - 1873.69	847.10 518.92 - 1382.82	166.06 <LOD - 540.99	802.56 425.28 - 1179.84	1202.72 880.45 - 1524.98	1833.63 1469.89 - 2197.37	3169.34 1922.56 - 4416.13	S
60–79	69	4.35	1516.66 1248.34 - 1784.98	982.98 705.62 - 1369.35	S	731.76 409.92 - 1053.59	1378.52 984.12 - 1772.93	1864.32 1365.09 - 2363.55	S	S
Females										
Total, age 12–79	398	4.02	1690.55 1405.04 - 1976.07	782.37 586.43 - 1043.79	100.55 <LOD - 268.92	478.10 273.53 - 682.68	1190.71 937.85 - 1443.58	2275.58 1756.15 - 2795.01	3686.87 2891.99 - 4481.76	5476.23 4377.44 - 6575.01
12–19	54	9.26	374.97 165.35 - 584.60	99.25 54.85 - 179.58	S	39.96 <LOD - 83.29	167.51 <LOD - 455.54	490.53 26.20 - 954.86	S	S
20–39	151	3.31	1334.90 1080.82 - 1588.98	680.06 451.56 - 1024.20	100.32 <LOD - 309.45	467.77 187.61 - 747.93	1122.41 756.27 - 1488.55	1890.69 1396.59 - 2384.79	2354.67 2049.54 - 2659.80	S
40–59	135	2.96	2241.96 1715.52 - 2768.39	1267.24 955.76 - 1680.22	307.93 <LOD - 481.87	751.30 517.64 - 984.97	1678.41 831.96 - 2524.87	3205.92 2444.68 - 3967.16	5399.98 3809.50 - 6990.45	S
60–79	58	3.45	1541.09 984.70 - 2097.48	728.65 356.99 - 1487.23	S	511.62 <LOD - 1023.63	1221.52 862.87 - 1580.18	1783.16 1105.49 - 2460.84	S	S

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

S Any estimate based on fewer than the minimum number of respondents required according to the *Statistics Act* must be suppressed in order to ensure respondent confidentiality. See Section 6.0, Statistical Data Analysis, for further information.

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APPENDIX A

Acronyms and Abbreviations

2,4-D	2,4-dichlorophenoxyacetic acid
2,4-DCP	2,4-dichlorophenol
ACGIH	American Conference on Governmental Industrial Hygienists
ADI	acceptable daily intake
AI	adequate intake
AM	arithmetic mean
As	arsenic
ATSDR	Agency of Toxic Substances and Disease Registry
BDE	brominated diphenyl ethers
BHC	benzenehexachloride
BPA	bisphenol A
BSEF	Bromine Science and Environmental Forum
CASRN	Chemical Abstract Services Registry Number
CCME	Canadian Council of Ministers of the Environment
Cd	cadmium
CDC	Centers for Disease Control and Prevention
CEC	Commission for Environmental Cooperation
CEPA 1999	*Canadian Environmental Protection Act, 1999*
CHMS	Canadian Health Measures Survey
CI	confidence interval
CIR	Cosmetic Ingredient Review
CTQ	Centre de Toxicologie du Québec
Cu	copper
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DDVP	dichlorvos
DEDTP	diethyldithiophosphate
DEP	diethyl phosphate
DETP	diethylthiophosphate
DHHS	Department of Health and Human Services (United States)
DMDTP	dimethyldithiophosphate

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DMP	dimethylphosphate
DMTP	dimethylthiophosphate
EAR	estimated average requirement
ECB	European Chemicals Bureau
EFSA	European Food Safety Authority
EI	electronic impact
EPA	Environmental Protection Agency
ESIS	European Chemical Substances Information System
FIMS	Flow Injection Mercury System
GM	geometric mean
GC-MS	gas chromatograph coupled to mass spectrometer
GC-MS-MS	gas chromatograph coupled to tandem mass spectrometer
HCB	hexachlorobenzene
HCH	hexachlorocyclohexane
Hg	mercury
HPV	High Production Volume
IARC	International Agency for Research on Cancer
ICP-MS	inductively coupled plasma mass spectrometry
INAC	Indian and Northern Affairs Canada
INSPQ	Institut national de santé publique du Québec
IOM	Institute of Medicine
IPCS	International Programme on Chemical Safety
IUPAC	International Union of Pure and Applied Chemistry
LFS	Labour Force Survey
LOD	limit of detection
LRTAP	Long-range Transboundary Air Pollution
MAC	maximum acceptable concentration
MEC	mobile examination centre
MMT	methylcyclopentadienyl manganese tricarbonyl
Mn	manganese
Mo	molybdenum
MRL	maximum residue limit
MRM	multiple reaction monitoring
MS	mass spectrometer
NCI	National Cancer Institute
ND	not detected
NHANES	National Health and Nutrition Examination Survey (United States)

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Ni	nickel
NIOSH	National Institute for Occupational Safety and Health
NLM	National Library of Medicine
NOAEL	No Observed Adverse Effects Level
NRCan	Natural Resources Canada
NTP	National Toxicology Program
NTP-CERHR	National Toxicology Program – Center for the Evaluation of Risks to Human Reproduction
OECD	Organisation for Economic Co-operation and Development
Pb	lead
PBB	polybrominated biphenyl
PBDE	polybrominated diphenyl ether
PCB	polychlorinated biphenyl
PFHxS	perfluorohexane sulfonate
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PMRA	Pest Management Regulatory Agency
POP	persistent organic pollutant
PSL	Priority Substances List
pTDI	provisional tolerable daily intake
PVC	polyvinyl chloride
RDA	recommended dietary allowance
SAS	Statistical Analysis System
Sb	antimony
Se	selenium
SIM	single ion monitoring
TDI	tolerable daily intake
TDS	Total Diet Study
UL	Upper Intake Levels
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UPLC	Ultra Performance Liquid Chromatography
US EPA	United States Environmental Protection Agency
US FDA	United States Food and Drug Administration
V	vanadium
WHO	World Health Organization
Zn	zinc
γ-HCH	lindane (gamma-hexachlorocyclohexane)

APPENDIX B

Limits of Detection for the Environmental Chemicals Measured in the CHMS

Laboratory analyses of environmental chemicals and creatinine were performed at the human toxicology laboratory of the Institut national de santé publique du Québec (INSPQ), Québec City. The INSPQ followed standardized operating procedures that were developed for every assay and technique performed in its laboratory. The laboratory is accredited under ISO 17025. For this report, the limit of detection (LOD) is defined as the lowest level that can be reasonably achieved within specified limits of precision and accuracy within routine laboratory operating conditions. Laboratory analysis of serum lipids was performed at the Health Canada laboratories, Bureau of Nutritional Sciences, Nutrition Research Division, Ottawa. Limits of detection for triglycerides and total cholesterol are defined as the low end of the manufacturer's stated dynamic range for the method.

Metals and Trace Elements in Urine	
Antimony	0.02 μg/L
Arsenic	0.52 μg/L
Cadmium	0.09 μg/L
Copper	0.32 μg/L
Lead	0.10 μg/L
Manganese	0.05 μg/L
Mercury, inorganic	0.10 μg/L
Molybdenum	0.09 μg/L
Nickel	0.17 μg/L
Selenium	6.32 μg/L
Uranium	0.009 μg/L
Vanadium	0.10 μg/L
Zinc	13.10 μg/L

Metals and Trace Elements in Blood	
Arsenic	0.23 μg/L
Cadmium	0.04 μg/L
Copper	0.64 μg/L
Lead	0.02 μg/dL
Manganese	0.05 μg/L
Mercury, total	0.10 μg/L
Mercury, inorganic	0.40 μg/L
Molybdenum	0.09 μg/L
Nickel	0.35 μg/L
Selenium	7.89 μg/L
Uranium	0.005 μg/L
Zinc	0.65 μg/L

Organochlorines	
Aldrin	0.01 μg/L
α-Chlordane	0.01 μg/L
γ-Chlordane	0.005 μg/L
cis-Nonachlor	0.005 μg/L
trans-Nonachlor	0.01 μg/L
Oxychlordane	0.005 μg/L
p,p'-DDT	0.05 μg/L
p,p'-DDE	0.09 μg/L
HCB	0.04 μg/L
β-HCH	0.01 μg/L
γ- HCH	0.01 μg/L
Mirex	0.01 μg/L
Toxaphene parlar 26	0.005 μg/L
Toxaphene parlar 50	0.005 μg/L

Polychlorinated Biphenyls	
PCB 28	0.05 µg/L
PCB 52	0.30 µg/L
PCB 66	0.03 µg/L
PCB 74	0.03 µg/L
PCB 99	0.03 µg/L
PCB 101	0.03 µg/L
PCB 105	0.01 µg/L
PCB 118	0.01 µg/L
PCB 128	0.01 µg/L
PCB 138	0.01 µg/L
PCB 146	0.01 µg/L
PCB 153	0.01 µg/L
PCB 156	0.01 µg/L
PCB 163	0.01 µg/L
PCB 167	0.01 µg/L
PCB 170	0.01 µg/L
PCB 178	0.01 µg/L
PCB 180	0.01 µg/L
PCB 183	0.01 µg/L
PCB 187	0.01 µg/L
PCB 194	0.01 µg/L
PCB 201	0.01 µg/L
PCB 203	0.01 µg/L
PCB 206	0.01 µg/L
Aroclor 1260*	0.01 µg/L

* Calculated value based on PCB 153 and PCB 138

Polybrominated Flame Retardants	
PBB 153	0.02 µg/L
PBDE 15	0.03 µg/L
PBDE 17	0.03 µg/L
PBDE 25	0.03 µg/L
PBDE 28	0.03 µg/L
PBDE 33	0.03 µg/L
PBDE 47	0.03 µg/L
PBDE 99	0.02 µg/L
PBDE 100	0.02 µg/L
PBDE 153	0.02 µg/L

Perfluorinated Compounds	
PFOS	0.3 µg/L
PFOA	0.3 µg/L
PFHxS	0.3 µg/L

Environmental Phenol	
Bisphenol A	0.2 µg/L

Organophosphate Insecticides (metabolites)	
DMP	1.0 µg/L
DMTP	0.6 µg/L
DMDTP	0.3 µg/L
DEP	1.0 µg/L
DETP	0.6 µg/L
DEDTP	0.3 µg/L

Pyrethroid Insecticides (metabolites)	
4-F-3-PBA	0.008 µg/L
cis-DBCA	0.006 µg/L
cis-DCCA	0.007 µg/L
trans-DCCA	0.01 µg/L
3-PBA	0.01 µg/L

Phenoxy Herbicide	
2,4-D	1.0 µg/L

Chlorophenol	
2,4-DCP	0.3 µg/L

Tobacco	
Cotinine	1.1 µg/L

Adjustment Factors	
Creatinine	0.31 mmol/L (0.035 µg/L)
Triglycerides	0.11 mmol/L (0.0974 g/L)
Total Cholesterol	1.29 mmol/L (0.4987 g/L)

APPENDIX C

Conversion Factors

Units of measurement are important. Results are reported here using standard units, however, units can be converted using the conversion factors presented below for comparison of data with other datasets.

Unit	Abbreviation	Value
litre	L	—
decilitre	dL	10^{-1} L
millilitre	mL	10^{-3} L
microlitre	µL	10^{-6} L
gram	g	—
milligram	mg	10^{-3} g
microgram	µg	10^{-6} g
nanogram	ng	10^{-9} g
picogram	pg	10^{-12} g

Data can be converted from µg/L to µmol/L using the molecular weight (MW) of the chemical using the formula:

> X µmol/L = X µg/L X conversion factor (CF), where the CF is equivalent to 1/MW

	MW (g/mol)	CF (µg/L → µmol/L)
Metals and Trace Elements		
Antimony	121.76	0.00821
Arsenic	74.92	0.01335
Cadmium	112.41	0.00890
Copper	63.55	0.01574
Lead	207.20	0.00483
Manganese	54.94	0.01820
Mercury	200.59	0.00499
Molybdenum	95.94	0.01042
Nickel	58.69	0.01704
Selenium	78.96	0.01266
Uranium	238.03	0.00420
Vanadium	50.94	0.01963
Zinc	65.39	0.01529
Organochlorine		
Aldrin	364.91	0.00274
α-Chlordane	409.78	0.00244
γ-Chlordane	409.78	0.00244
cis-Nonachlor	444.22	0.00225
trans-Nonachlor	444.22	0.00225
Oxychlordane	423.76	0.00236
β-HCH	290.83	0.00344
γ-HCH	290.83	0.00344
p,p'-DDT	354.49	0.00282
p,p'-DDE	318.03	0.00314
HCB	284.78	0.00351
Mirex	545.54	0.00183
Parlar 26	170.68	0.00586
Parlar 50	170.68	0.00586

	MW (g/mol)	CF (µg/L → µmol/L)
Polychlorinated Biphenyls		
PCB 28	257.54	0.00388
PCB 52	291.99	0.00342
PCB 66	291.99	0.00342
PCB 74	291.99	0.00342
PCB 99	326.44	0.00306
PCB 101	326.44	0.00306
PCB 105	326.44	0.00306
PCB 118	326.44	0.00306
PCB 128	360.88	0.00277
PCB 138	360.88	0.00277
PCB 146	360.88	0.00277
PCB 153	360.88	0.00277
PCB 156	360.88	0.00277
PCB 163	360.88	0.00277
PCB 167	360.88	0.00277
PCB 170	395.33	0.00253
PCB 178	395.33	0.00253
PCB 180	395.33	0.00253
PCB 183	395.33	0.00253
PCB 187	395.33	0.00253
PCB 194	429.77	0.00233
PCB 201	429.77	0.00233
PCB 203	429.77	0.00233
PCB 206	464.21	0.00215
Aroclor 1260	n/a	—
Polybrominated Flame Retardants		
PBB 153	627.59	0.00159
PBDE 15	328.00	0.00305
PBDE 17	406.90	0.00246
PBDE 25	406.90	0.00246
PBDE 28	406.90	0.00246
PBDE 33	406.90	0.00246
PBDE 47	485.79	0.00206
PBDE 99	564.69	0.00206
PBDE 100	564.69	0.00177
PBDE 153	643.59	0.00155
Perfluorinated Compounds		
PFOS	500.13	0.00200
PFOA	414.07	0.00242
PFHxS	400.11	0.00250

	MW (g/mol)	CF (µg/L → µmol/L)
Environmental Phenol		
Bisphenol A	228.29	0.00438
Organophosphate Insecticides (metabolites)		
DMP	126.05	0.00793
DMTP	142.11	0.00704
DMDTP	158.18	0.00632
DEP	154.10	0.00649
DETP	170.17	0.00588
DEDTP	186.24	0.00537
Pyrethroid Insecticides (metabolites)		
4-F-3-PBA	232.21	0.00431
cis-DBCA	297.97	0.00336
cis-DCCA	209.07	0.00478
trans-DCCA	209.07	0.00478
3-PBA	214.22	0.00467
Phenoxy Herbicide		
2,4-D	221.04	0.00452
Chlorophenol		
2,4-DCP	163.00	0.00613
Tobacco		
Cotinine	176.22	0.00567
Adjustment Factor		
Creatinine	113.118	0.008840

APPENDIX D

Creatinine

Creatinine

Creatinine – Arithmetic and geometric means and selected percentiles of urine concentrations (mg/dL) for the Canadian population aged 6–79 years, Canadian Health Mesures Survey Cycle 1, 2007-2009.

	n	%<LOD[a]	A.M. 95% CI	G.M. 95% CI	10th 95% CI	25th 95% CI	50th 95% CI	75th 95% CI	90th 95% CI	95th 95% CI
Total, age 6–79	5515	0.22	108.34 104.11 - 112.57	82.97 77.71 - 88.60	27.33 23.80 - 30.86	50.63 44.88 - 56.37	93.10 86.06 - 100.14	148.53 142.93 - 154.12	214.03 204.36 - 223.70	251.21 242.66 - 259.76
6–11	1042	0.29	82.12 77.05 - 87.18	65.6[illegible] 60.04 - [illegible]	24.14 [illegible].88 - 29.39	44.01 36.46 - 51.55	74.64 67.53 - 81.74	109.80 102.55 - 117.04	148.54 137.32 - 159.76	174.80 164.43 - 185.17
12–19	992	0.10	143.12 132.29 - 153.96	115.29 105.04 - 126.54	38.82 30.15 - 47.49	79.38 65.02 - 93.73	132.88 121.50 - 144.26	189.44 176.22 - 202.65	260.41 229.96 - 290.86	298.65 260.88 - 336.43
20–39	1172	0.34	117.69 109.65 - 125.73	90.01 80.85 - 100.20	29.50 22.43 - 36.56	56.21 46.71 - 65.72	101.06 89.47 - 112.65	161.77 153.38 - 170.16	230.05 216.96 - 243.15	279.35 254.11 - 304.59
40–59	1221	0.25	103.36 99.02 - 107.70	78.23 73.30 - 83.49	23.79 18.84 - 28.73	45.62 38.66 - 52.58	86.76 76.74 - 96.78	146.48 138.92 - 154.04	209.06 188.48 - 229.65	243.92 230.90 - 256.95
60–79	1088	0.09	89.44 85.18 - 93.70	71.54 67.88 - 75.39	26.42 21.84 - 31.00	44.37 39.36 - 49.37	81.15 77.15 - 85.14	120.57 111.72 - 129.41	159.51 148.84 - 170.19	197.86 171.84 - 223.88
Males										
Total, age 6–79	2663	0.26	126.15 122.21 - 130.09	101.40 96.55 - 106.51	36.22 28.57 - 43.86	66.85 60.22 - 73.48	113.52 107.32 - 119.73	167.93 157.45 - 178.40	235.03 222.69 - 247.36	269.93 256.90 - 282.95
6–11	526	0.38	82.00 74.22 - 89.78	66.41 56.83 - 77.60	24.69 15.03 - 34.34	46.87 36.33 - 57.42	73.41 64.73 - 82.08	109.87 99.05 - 120.68	143.40 132.45 - 154.34	172.15 162.30 - 182.01
12–19	505	0.20	142.56 131.50 - 153.61	118.31 107.49 - 130.22	44.94 31.36 - 58.52	87.54 73.46 - 101.62	132.04 118.48 - 145.60	187.92 170.60 - 205.24	241.16 216.11 - 266.20	285.28 255.60 - 314.96
20–39	515	0.39	139.03 127.04 - 151.03	109.01 95.14 - 124.89	33.86 17.28 - 50.44	73.83 60.51 - 87.15	125.18 108.90 - 141.46	194.84 168.23 - 221.46	269.25 238.27 - 300.24	295.30 278.48 - 312.11
40–59	575	0.35	126.43 117.70 - 135.17	102.06 95.68 - 108.86	36.05 27.34 - 44.75	64.57 57.80 - 71.34	115.01 101.60 - 128.41	172.33 142.48 - 202.18	241.84 219.09 - 264.60	253.22 244.08 - 262.36
60–79	542	0.00	109.48 100.68 - 118.27	94.86 87.46 - 102.88	43.04 37.65 - 48.43	69.84 61.05 - 78.62	102.64 89.07 - 116.22	141.58 127.48 - 155.69	178.55 147.59 - 209.50	213.98 196.84 - 231.12
Females										
Total, age 6–79	2852	0.18	90.68 84.48 - 96.89	68.01 62.19 - 74.37	22.17 18.83 - 25.52	39.35 33.80 - 44.89	75.23 66.22 - 84.25	124.23 114.62 - 133.84	180.93 167.37 - 194.49	217.01 202.07 - 231.95
6–11	516	0.19	82.25 75.75 - 88.75	64.82 58.97 - 71.26	22.53 17.23 - 27.83	40.71 32.60 - 48.82	76.43 65.52 - 87.35	109.60 99.91 - 119.29	154.46 136.14 - 172.78	179.52 158.32 - 200.72
12–19	487	0.00	143.73 128.87 - 158.60	112.11 97.50 - 128.91	36.32 23.33 - 49.31	73.07 51.06 - 95.08	133.79 120.42 - 147.16	192.41 169.62 - 215.21	262.21 220.23 - 304.19	316.25 264.72 - 367.77
20–39	657	0.30	96.37 89.26 - 103.48	74.33 66.85 - 82.65	25.15 19.27 - 31.03	47.47 40.20 - 54.74	80.17 67.76 - 92.57	130.95 118.04 - 143.85	186.87 174.77 - 198.98	222.17 203.29 - 241.06
40–59	646	0.15	80.60 73.23 - 87.98	60.18 53.73 - 67.40	19.75 15.89 - 23.60	32.09 23.60 - 40.59	66.00 54.17 - 77.83	117.06 106.72 - 127.41	160.73 141.31 - 180.15	193.86 172.23 - 215.50
60–79	546	0.18	71.16 64.36 - 77.96	55.30 49.20 - 62.17	20.23 15.25 - 25.21	34.97 28.13 - 41.81	55.87 47.21 - 64.52	93.61 85.78 - 101.44	135.73 122.84 - 148.63	161.60 147.03 - 176.18

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.